How the CRM Came of Age, And Then Some

It was 1976 when Brick Dumas and his staff in the Space Systems Department began to design a special payload — one that could, for the first time, detect from space an aboveground nuclear burst. The payload would be carried by the new Global Positioning System (GPS) satellites being developed for the Department of Defense (DoD).

But before they could hope to detect man-made radiation with the GPS system, they had to solve a radiation problem presented by Mother Nature.

The Sandians wanted their GPS payload to use microprocessor logic — logic similar to the circuits that control modern personal computers. But they knew that no microprocessor then in existence would work in those satellites.

That's because the constellation of GPS satellites (some of which still await launch today) would travel through a zone of extremely intense natural radiation — the Van Allen belts — during their circular orbit almost 11,000 miles above the earth.

"While passing through this region of space, our payload's microelectronics would get a pretty potent dose of radiation, both periodic jolts of radiation and a gradually accumulated total dose," recalls Brick, now manager of Space Systems Department 9210.

The radiation could make microprocessor transistors switch on and off at incorrect times. Or it could cause information stored in the memory chips connected to the microprocessor to vanish temporarily, even permanently.

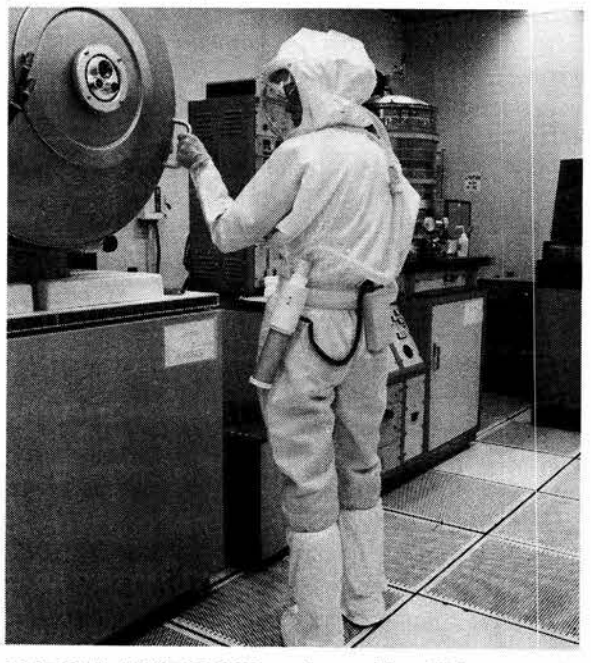
"We needed microprocessors and associated chips that were hardened against the effects of radiation," Brick says.

Solution Already Under Way

In the early 70s, a group of forward-looking Sandians, led by Klaus Bowers (then VP for Research and now AT&T Bell Labs VP for Electronics Technology), had set out to close the technology gap that existed between Sandia's radiation effects research and the production capability that existed in the U.S. semiconductor industry.

"Essentially, we initiated the early hardening work by marching in to talk with RCA," says Bill Spencer, who arrived at Sandia in 1973 as Director of Microelectronics. "We wanted to discuss how we could increase the radiation tolerance of an RCA microprocessor by 10 times.

"Why? Because we knew that someone would soon be eager to get some microelectronics that could survive severe radiation exposure," adds Bill, now Xerox VP of Corporate Research in Stamford, Conn.



SPECIAL UNIFORMS such as this will be worn in the fabrication clean room of the new RHIC-II facility. The clean room suit filters the air exhaled by the wearer before passing it back into the clean room environment. A person in street clothing could add as many as a million particles per minute to the clean room area.

THESE CHIPS, displayed by VP Larry Anderson (2000) and Liz Lujan (2151), will go far. Or at least some of them will. Package contains a radiation-hardened 16K static random access memory chip like the kind designed for use on NASA's Project Galileo space mission to Jupiter. Several hundred such parts will be used in the Galileo probe, which is scheduled to dip into the Jovian atmosphere.

SANDIA LABORATORY NEWS

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"That someone turned out to be a fellow Sandian."

But that's getting ahead of the story. Based on those discussions with RCA, Bob Gregory's 30-person Integrated Circuit Process Department began the pioneering work that resulted — within two years (a quick turnaround time in the microelectronics industry, even today) — in prototypes of that first radiation-hardened microprocessor, along with the world's first radiation- hardened read-only memories (ROMs) and random-access memories (RAMs). This early work started in a small second-floor lab in Bldg. 802 and moved to the Bldg. 870 wafer fabrication facility, then called the Semiconductor Development Laboratory.

The Labs' early work brought with it a rapid accumulation of knowledge about this special type of microelectronics. In fact, as early as April 1975, during a Sandia Management Conference at Bishop's Lodge, Bill confidently reported, "I now feel that Sandia definitely has more information on what makes hardened oxides for metal oxide semiconductor devices than any other organization in the country."

"There really is no single event that prompted the evolution of the rather modest radiation-hardening effort of those days into today's Center for Radiation-hardened Microelectronics [CRM]," says Bob, now Director of Microelectronics 2100. "But the needs of Brick Dumas and his satellite payload designers, coupled with our ability to develop and produce what the satellites needed, certainly were a springboard."

The CRM, formally established in 1980, now employs some 400 persons from three primary organizations, with a combined FY87 budget of about $75 million. It develops new, increasingly complex designs for radiation-hardened microelectronics. It identifies ways to make those chips (see "Hardening Chips" story). It makes chips for a variety of DOE programs when those parts aren't available from a commercial manufacturer. And it strives to transfer any of its unique know-how — whether it's about radiation-hardening or about IC design and fabrication as a whole — to industry (see "Here It Is, If You Want It" story).

Since its 1980 founding, none of the approximately 200,000 high-reliability radiation-hardened parts delivered to the CRM's various customers has failed in deployed systems. More than 20,000 of that sum went to NASA for use on its Project Galileo spacecraft, which will enter Jupiter's atmosphere. Some also are orbiting the earth in SPOT, a French photo-reconnaissance satellite.

CRM Special Issue

Microelectronics has a powerful influence on virtually every program, weapon and nonweapon, at Sandia. And often those microelectronic components are built in, or procured through, the Labs' Center for Radiation-hardened Microelectronics. Because of the CRM's impact, much of this issue is devoted to the CRM — its whos, whats, hows, and whys, its past, its present, its future.

It's not surprising then that many radiation-hardened chip users and leaders in the U.S. semiconductor industry view the CRM as a prime source for radiation-hardening technology:

John Casani, Project Galileo director at the Jet Propulsion Laboratory, says, "CRM's work on hardening microelectronics against the peculiar effects of single-event upset was absolutely critical to the success of our mission. The Center's quick solution to the problem avoided the need to develop a new computer for the spacecraft."

J. S. Kilby, chairman of the Advisory Group on Electron Devices, Office of the Under Secretary of Defense, has said, "The work of the CRM is essential to hardening modern weapon systems. The

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Radiation Hardening of Microelectronics

Speaking the Right Language: A Glossary of Terms

Angstrom — Unit of length equal to one 10-billionth of a metre. Human hair measures about 750,000 angstroms in diameter.

Asynchronous operation — Operation mode that permits an IC to complete multiple functions — addition of two numbers, for instance — between ticks of its clock. (Compare "Synchronous.")

Bit — Abbreviation of binary units, one of the two numbers — 0 and 1 — used to encode computer data in a chip's memory. It takes several bits to record a meaningful piece of information, the letter "A," for instance.

Burn-out — Permanent destruction of an IC. Caused by a sizable dose of radiation, which makes so much current flow that a portion of the device overheats.

Chip — A single IC cut from a silicon wafer that contains many ICs.

Clock — Set of oscillating transistors on an IC that determines the time base for that IC's operation. Chip with a clock operating at 20 megahertz oscillates 20 million times a second.

Complementary metal oxide semiconductor (CMOS) — Major IC device structure suited to radiation hardening because it consumes little power and displays good noise immunity. Many applications for logic and memory. A CMOS part with features as small as two microns is called a 2-micron CMOS chip. CRM's most mature, reliable CMOS technology, the one used by the Center's BAO production branch, is called 4/3 CMOS. This means 4-micron-wide conducting lines and spacings and 3-micron-long transistor gates. An earlier, now obsolete CRM technology was called 7/4 CMOS.

Die — Synonymous with chip.

Dose rate — Radiation exposure per unit of time. Normally expressed in rads/sec. Also called gamma dot.

Etching — Selective removal of unwanted material from a silicon wafer surface during processing.

Field oxide — Relatively thick dielectric film (about 6000 angstroms) that electrically isolates active IC regions (transistors, for example).

Gate — Voltage-controlled on-off switch contained in a transistor. Applying threshold voltage to a transistor's gate turns on device and current flows through it.

Gate array — IC with many gates whose interconnections can be programmed to perform a specific task. Analogous to a pre-fab building that can take any of several usable forms, depending on final assembly.

Gate oxide — Thin dielectric layer (typically 300 to 500 angstroms) of silicon dioxide that electrically isolates a transistor's gate from its underlying channel, the part of the transistor through which current actually flows.

Integrated circuit (IC) — Chip of silicon containing a combination of many transistors and their electrical interconnections. Designed to perform a specific task.

Ionizing radiation — Radiation from a number of sources — photons from gamma or X-rays and charged particles such as electrons, protons, alpha particles, beta particles, and ions. Ruins an IC by depositing unwanted electrical charge in the device or by altering its crystalline structure.

K — A general abbreviation for kilo (1000). A 1K memory chip holds 1024 bits. A 64K memory stores 65,536 bits.

Latchup — Condition in which a device "latches" into an inoperative condition. Device will typically draw excessive current and can be returned to operating condition only through removal and reapplication of power.

Lot — A batch of 25-100 silicon wafers processed at the same time.

Memory cell — Portion of IC where bits of information are stored in the form of electrical charges. Typical radiation-hardened static RAM uses six transistors per memory cell.

Memory chip — IC containing many memory cells and dedicated to storing many bits.

Micron — Short for micrometre, a unit of length equal to one millionth of a metre. Diameter of a human hair is about 75 microns.

Neutron radiation — Particle radiation consisting of neutrons. CMOS ICs typically are not harmed by this type of radiation.

Nonvolatile memory — Special kind of memory chip that does not require continuous current to retain programmed information.

Photolithography — Photographic technique for defining geometic patterns in IC fabrication.

Photomask — Glass plate that contains patterning information transferred to silicon wafer during IC fabrication. Outlines route of conducting lines, etc.

RAD (Radiation Absorbed Dose) — Unit of ionizing radiation energy absorption. Whole-body dose of about 1000 rads of ionizing radiation is typically fatal to humans.

RAD (Si) — The quantity of any type of ionizing radiation that impacts 100 ergs of energy into 1 g of silicon.

Radiation-Hardened Integrated Circuit Laboratory - II (RHIC-II) — Newest major CRM facility; still under construction at Sandia. RHIC-II will have a unique 12,500-square-foot Class 1 clean room for wafer fabrication, meaning that less than 1 particle of 0.12-micron size or larger will be present per cubic foot of air space. Replaces RHIC-I, formerly called Semiconductor Development Lab, in Bldg. 870.

Radiation-hardening — Special design and fabrication techniques that permit ICs to survive exposure to intense radiation found in space or weapon environments.

Random-Access Memory (RAM) — Memory chip in which a piece of information can be independently stored or retrieved. Contents are only held temporarily.

Read-Only Memory (ROM) — Memory chip in which information is permanently stored during manufacturing.

Semiconductor — Any element (silicon or germanium, for instance) with an electrical conductivity less than that of a conductor (copper) and greater than that of an insulator (glass). Transistors and diodes are semiconductors.

Silicon On Insulator (SOI) — A special type of CMOS IC that uses a 1000-2000 angstrom silicon dioxide film just above the device's silicon substrate, but below the active silicon layers, as a means of enhancing electrical isolation between active IC parts. Possibly a requirement for radiation-hardened parts with submicron features.

Single-Event Upset (SEU) — Temporary scrambling of one or more memory bits due to a high-energy particle or cosmic ray hitting a memory cell.

Standard cell — IC component whose photomask and operating features are defined in a computer memory of a design workstation.

Synchronous operation — IC operation that performs logic functions only when its clock ticks.

Test chip — Special wafer segment that contains small pieces (odds and ends, in essence) of a complete IC. Used to determine whether actual chips will perform as designed.

Total dose — Amount of ionizing radiation accumulated by a substance over time. IC fails if it exceeds its total dose tolerance.

Threshold voltage — Voltage required to open a transistor gate so that electricity will flow through it.

Transient upset — Temporary loss or severe degradation of device performance following an extremely strong burst of ionizing radiation. Includes latchup and logic upset.

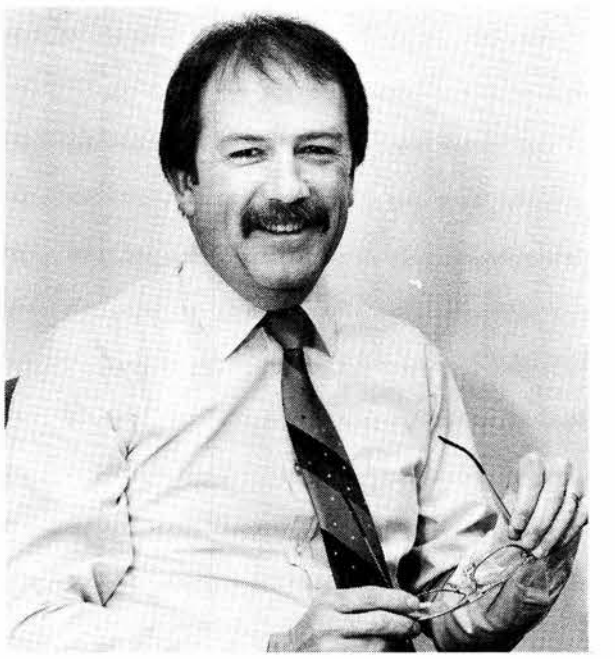
Transistor — Semiconductor device that acts primarily as an amplifier or as a current switch.

Van Allen belts — Belts of intense ionizing radiation that surround the earth in the exosphere, between approximately 500 and 33,000 miles above the earth. Contain particles carrying energies from 20,000 to more than one million electron volts.

Very Large Scale Integrated (VLSI) circuit — IC with hundreds of thousands, or even millions, of individual elements, and more than 64,000 bits of memory.

Wafer — Round, thin, polished slice of crystalline silicon on which many ICs are fabricated. CRM typically uses wafers 4 or 6 inches in diameter.

Yield — The percentage of individual ICs on a wafer that operate properly. A 50 percent yield means that half the ICs on a wafer work.



DALE CLEMENTS, Manager of Bendix Albuquerque Operation (BAO)

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CRM

DoD is critically dependent upon it."

Says W. G. Howard Jr., Motorola Senior Vice-President, "The CRM's semiconductor capability is the strongest our government has. Neither DoD nor private industry can fill the special needs supported by such a dedicated facility."

The GPS story illustrates the commitment to service toward which the CRM always strives. "The CRM is people working to render a service," offers Bill Lovejoy, supervisor of CRM Program Development/Management Division 2151.

However, quick descriptions, despite their succinctness, don't provide a complete picture of this complex, diverse organization. The fact that the CRM is located at Sandia probably leads to one of the most widely held misunderstandings about the place.

Only about half of its employees are Sandians. Together they form Sandia's 2100 Organization and the R&D branch of the Center, which has the IC (integrated circuit) R&D mission for the nuclear weapon complex.

The other half of the CRM's work force is employed primarily by Bendix Albuquerque Operation (BAO), a Department of Energy (DOE) contractor, or by Kirk-Mayer, a local manpower contractor. The BAO/Kirk-Mayer group performs production as required to support the microelectronics needs of the nuclear weapon complex (see "BAO Begins Producing" story).

Sandia administers some $55 million of the CRM's $75 million operating budget in FY87; the remainder is BAO's responsibility.

Dale Clements is BAO manager, and thus in charge of CRM's production operation. "To be successful," he says, "the CRM must operate as one company, even though it has two distinct missions. This is illustrated by the increasing importance, throughout the entire semiconductor industry and not just at the CRM, for circuit designers and chip processors to work closely together — almost hand-in-hand — over the entire development span of a chip."

The Center's organizational structure, nonetheless, gives Sandia sole responsiblity for some tasks; it gives BAO sole responsibility for others; and it provides for some overlap.

This overlap means that the Sandia and BAO organizations both have occasion to hire people with similar backgrounds in IC fabrication and processing. Sandians with this expertise develop new fabrication techniques that accompany new microelectronics parts, while BAO fabrication specialists produce CRM-proven mature technology parts that have been ordered by customers. Also, in order to ensure the most efficient CRM operation, development and production people frequently share ideas.

"Design and fabrication of radiation-hardened silicon ICs is arguably one of the most difficult challenges in this modern high-tech age," says Doug

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CRM

Weaver, manager of IC Operations & Prototype Labs Department 2130. "It can be necessary to redesign parts from their original prototypes or to adjust processing procedures if problems occur. Consequently, it is one of the most expensive modern technological challenges, although we regularly run into people who simply have no idea just *how* difficult and expensive."

Developing a new IC technology — reducing the size of transistors on an IC from three to two microns, for instance — can take up to three years. Costs, including proof of manufacturability, typically reach $20 million to $25 million.

Then, when the process line begins to flow, it can take three CRM fabrication shifts working six days a week up to 10 weeks to produce one lot of wafers (that's 25) containing the new type of chips.

When all this is factored together, along with the extensive testing requirements, it means that radiation-hardened ICs frequently cost 200 times more than their non-hardened commercially available equivalents.

"Working with something so expensive can be pretty taxing," Doug confesses.

"Another thing that makes IC processing especially stressing," he continues, "is that everything done for that eight- to ten-week fabrication period is physical — application of many different layers to a substrate, removal of photoresist, and such. However, none of those physical processes directly tells you whether the device will work electrically. You just wait until fabrication is complete to learn that."

CRM Customers, In-House and Out

The CRM has two basic types of customers (see "A Customer's Guide" story). The "in-house" group — primarily organizations 2300, 5100, and 8100 — typically needs a regular supply of the Center's established radiation-hardened parts for ongoing weapon projects such as Trident II and the Code-Activated Processor. These parts — a microprocessor, a RAM and a ROM, and a collection of custom ICs — have features as small as three microns and can survive a total dose of ionizing radiation more than 100 times the level that would kill a human instantly.

In-house customers also depend on the CRM to develop new types of ICs and to obtain a wide range of radiation-hardened parts from the semiconductor industry. Some of these commercial parts have resulted from the transfer of CRM designs and technologies, but most are hardened, high-reliability equivalents of conventional non-hardened commercial parts.

The second customer group is government organizations — the Air Force and NASA are prime examples — that seek out the CRM for its more newly developing technologies.

The Sandia satellite developers in Organization 9000 fall between these two primary customer groups.

The new ICs being developed by the CRM have two-micron features. As they are improved, they should ultimately be of interest to CRM's in-house customers.

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How to 'Rad-Harden'

Hardening Chips: Some Science, Some Art

The design and manufacture of radiation-hardened ICs has been called a combination of science and art. Worldwide, many microelectronics experts consider this expertise to be synonymous with Sandia.

During the past decade, Sandia has been the leading supplier of high-density hardened parts for satellites and nuclear weapons. It has transferred its know-how to several commercial firms that are now beginning to provide their own chips.

Nevertheless, even though the CRM has become expert in this field, the hardening process remains extremely difficult, especially because of the demand for circuits of ever-decreasing size and increasing complexity. IC hardening is particularly difficult because many of the tricks of the trade used by designers and builders of non-hardened chips — the types in PCs, cars, VCRs — just can't be used at the CRM. To do so would compromise hardness at an unacceptable level. Unusually low processing temperatures required for hardening lead to a myriad of additional difficulties. Similarly, the use of certain "tried and true" materials is forbidden when building a radiation-hardened circuit.

The list goes on.

The primary categories of radiation effects that the CRM must guard against are total dose and dose rate (caused by ionizing radiation from gamma and/or X-rays) and single-event upset (SEU). Exposure to ionizing radiation can result in degraded performance, complete failure, or memory loss. SEU causes temporary, but critical, memory loss.

What Radiation Does

Ionizing radiation causes a buildup of unwanted electrical charges. These charges alter the device's threshold voltage so that transistors, depending on their type, are either permanently turned on or are too difficult to turn on. In either case, they are no longer a good switch. Unwanted electrical charges also slow the speed of a transistor's operation so that, for instance, a microprocessor that is typically used in a computer's central processing unit executes instructions too slowly.

SEU is a fairly recent discovery. It manifested itself as feature sizes shrank. When a high-energy particle or cosmic ray passes directly through a transistor, it suffers a voltage surge that scrambles binary digital information (1s become 0s, and vice versa). This causes a temporary memory loss. As feature sizes on chips become smaller, SEU will become an even more severe problem.

"At the CRM we accomplish radiation hardening via two paths," explains Chuck Gibbon, manager of Integrated Circuit Technology Department 2140. "First, we design a chip to be radiation-hard. Then, when processing takes place, we employ special techniques.

"This approach does not protect a chip from radiation damage," Chuck points out. "One widely held misconception is that radiation hardening shields parts and stops degradation. The performance of radiation-hardened ICs, in fact, suffers substantially during exposure." Because of this, CRM designers must anticipate and allow for that radiation-induced performance degradation. Their key tools include using static RAMs instead of the more common and efficient dynamic ones; using synchronous operation, not the faster, more space-efficient asynchronous type; and adhering to a "special," conservative design philosophy.

Only When the Clock Ticks

Wilson Barnard, supervisor of Special Processors Division 2116, says that synchronous logic design is probably the most efficient way of adapting to performance degradation caused by radiation. Synchronous IC systems perform functions — for instance, adding two numbers together — only when an IC's clock ticks. Because exposure to radiation slows completion of a function, a radiation-hardened design must ensure that the function is completed before the subsequent clock tick occurs. If the clock does tick before the function is complete, the wrong answer will result. By using synchronous operation, clock ticks can be adequately spaced, or timed, to ensure proper operation.

The debit is reduced speed. Chips with synchronous operation can't perform as many functions in a given period as asynchronous systems, which complete several functions between clock ticks.

CRM chip designers also use static RAMs because radiation exposure causes bits of dynamic RAM memory (electrical charges stored in capacitors) to leak away. Static RAMs store information in binary form — as a collection of 1s and 0s that are trapped in a group of memory cell transistors. This more stable electrical condition is not susceptible to ionizing radiation. (The 1s and 0s, however, can be scrambled by SEU, so designers must contend with that occurrence.)

The trade-off here also is severe. The dynamic RAM requires just one transistor and one capacitor per memory cell; the cell of a static RAM requires six transistors, and thus more valuable chip "real estate."

CRM designers also spend considerable time in front of computer screens simulating all possible faults that could befall a design.

Must Know Device Physics

"For successful processing," says Chuck, "we've had to learn the device physics of the transistors and other circuit elements, and how they are affected at the atomic scale by various kinds of radiation.

"We've also learned how fabrication processes — patterning, oxide deposition, ion implantation, and such — affect device sensitivity to different radiation sources."

"We use very thin layers of oxide to form the working and insulative parts of the device — as thin as we can without compromising reliability," explains Peter Winokur, of Advanced Microelectronics Development Division 2144. For example, the gate oxide layer of a radiation-hardened chip frequently is substantially thinner than its non-hardened equivalent." This means that gate oxides for the CRM's two-micron feature parts are just 350 angstroms thick. (An angstrom is one 10-billionth of a metre.)

Reducing these thicknesses decreases the sensitivity of transistors to ionizing radiation because it limits the amount of unwanted charge that can accumulate in those layers. That keeps threshold voltage shifts within acceptable ranges.

But extremely thin oxide layers increase the importance of precise processing. Any imperfection in one of those layers could ruin the chip by causing an electrical short.

After the gate oxide layer is grown onto the substrate, CRM processors must ensure that all additional processing steps use temperatures lower than the temperature of the gate oxide growth steps. That's in the neighborhood of 900 to 1000 degrees C, depending on the type of chip being made, versus the 1100 degrees C that's available to commercial processors. Use of those higher temperatures would alter the gate oxide's atomic structure, compromising hardness. The restriction against higher processing temperatures increases the difficulty of many of the later fabrication steps.

Two other critically important processing requirements are to minimize the amount of hydrogen present in fabrication equipment and to curtail or alter radiation-producing fabrication steps.

BAO Begins Producing WR-Quality Parts For Two Major Weapon Projects

By the end of this year, the CRM expects to have built and delivered more than 5000 fully qualified ICs — many of them custom designs — for two of Weapon Development 5100's major projects — the Trident II (T-II) warhead and Code-Activated Processor (CAP).

The ICs, already in production, represent the initial portion of the first CRM fabrication/packaging/qualification job to be conducted totally by its Bendix Albuquerque Operation (BAO) arm.

During FY88 and 89, the CRM will up its production of those parts to about 12,000 a year.

"From the late 70s and through the first several years of the 80s, radiation-hardened chips fabricated in Bldg. 870 were sent to Bendix Kansas City for packaging and qualification testing," says Dale Clements, BAO Manager at the CRM. "Then, beginning in 1985 [as BAO began to be established as the Center's production arm], the chips were made and packaged in Albuquerque. However, they still went to Kansas City for qualification before being used.

"But, beginning with T-II and CAP, and with all subsequent requests for parts made in mature CRM technologies, production — from wafer processing through to WR [war reserve] qualification — will be done by the Center's BAO branch," Dale explains.

(Any item in the nuclear weapon stockpile must wear a WR label, which means that it has undergone a full spectrum of quality and radiation-hardening certification exams.)

The T-II project calls for 16 distinct device types — ROMs, RAMs, nonvolatile RAMs, microprocessors, logic chips, and a variety of custom parts that tie all the other chips together — for use in the warhead's programmer, timer, radar, joint test assembly, and force-balance-integrating accelerometer.

The CAP, essentially a new-generation Permissive Action Link (PAL), requires eight device types, including ROMs and RAMs; a nonvolatile memory and a custom part that powers that memory; and a microprocessor.

T-II and CAP radiation-hardened ICs are built with the CRM's 4/3 CMOS technology, which means parts with four-micron-wide metal conducting lines and spacings between lines, and transistor gate lengths of three microns.

Vital to Success

"The T-II and CAP projects are dependent on the CRM for their success," says John Crawford, 5100 director. "The Center had to design and build several custom parts for us and for 2300 to meet the needs of these projects. Also, we had to rely on some of the CRM's pre-existing parts, like the microprocessor, that weren't available from other sources."

BAO began supplying what are called Process-Prove-In Units for the T-II and CAP projects last June; it completed CAP delivery last December. These units are the first packaged parts built with the exact tools and fabrication processes required for WR qualification. "Their purpose," Dale explains, "is to demonstrate reliable manufacturability, and a part's ability to function reliably."

The CAP mission required about 125 Process-Prove-In Units. T-II requires about 250, which are expected to be delivered by spring.

"We're also now qualifying and delivering the pilot production and tool-made sample quantities — about 300 parts for each program," says Al Bendure, BAO's Production Operations manager. "The latter units in this delivery cycle are destined for some full system tool-made samples that may actually enter the stockpile."

Reaching this production/packaging/qualification capability hasn't been without challenge, Dale points out. "During the past two years, for example, we've supplied almost 3000 development parts for installation in a variety of T-II test and evaluation subsystems and components. During that period we needed a number of design changes that required production halts and restarts.

"Also, last October, shortly after we'd begun packaging the initial T-II and CAP WR parts, we — the BAO side of the CRM — shut down our production packaging operation because fewer than half of the finished parts were passing the stringent hermetic seal requirements," Dale says.

"Once the shutdown was in place, we formed a dedicated team — Sandia and BAO members of the CRM — that essentially worked around the clock, seven days a week, for about two months, to identify the problems so that the line could begin flowing again."

As it turned out, the CRM study team found no single, simple solution to the problem, but it did uncover a variety of problems that had led to improperly sealed packages. "We identified concerns such as cleanliness of some packaging materials, inadequacies of equipment that sealed packages, and basic incompatibilities between IC packages and lids," Dale recalls.

"In retrospect," he adds, "some of the problems should have been identified before fabrication started. Indeed, some were examined a number of years ago, but CRM evaluations suggested that the concerns were manageable. However, when production volumes increased, we learned otherwise.

"The shutdown was controversial, particularly in the minds of various customers who needed the parts they'd ordered. But I think the wisdom of that shutdown is demonstrated in the yields we're now getting. Since restarting the packaging operation," Dale says, "the yields through sealing tests have been higher than ever before."

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CRM

In the meantime, John Crawford, Director of Weapon Development 5100, says he actually prefers to rely on what some people may consider to be the less-sophisticated radiation-hardened technology available from the CRM. "There may be a driving force in the future for two-micron ICs in new weapon systems," he says, "but right now I'm more interested in demonstrated high reliability, IC delivery schedules, and low cost."

Component Development VP Larry Anderson, in whose organization the CRM is located, echoes that sentiment: "We don't try to push the state-of-the-art for internal customers, who, after all, are dealing with nuclear weapons. Safety and reliability must be paramount.

"The CRM's external customers, on the other hand, actually are drawn by its developmental, high-risk radiation-hardened devices," Larry adds.

About 40 percent of the R&D performed by the CRM is for non-DOE customers. That's by design. And it's a decision based primarily on economics.

National Security Resource

"We decided several years ago," Bob Gregory explains, "that we needed a broad customer base in order to continue as a viable, attractive national security resource. Since that time, we've been seeking appropriate reimbursable work to help fund operations necessary to fulfill our DOE commitment."

"But we are selective about those external customers, and we decline some jobs," Larry empha-

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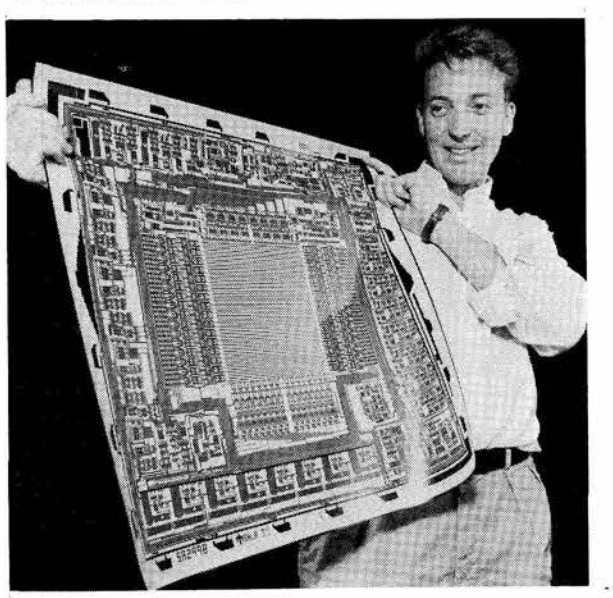


KEY PART that BAO has supplied for Sandia's Trident II effort is a nonvolatile memory that stores flight information. Photos show that radiation-hardened part in three forms. Above, Cathy Frank, a quality control inspector for BAO contractor Kirk-Mayer, holds a packaged part like those that will be used in the system. Louis Sanchez, BAO general inspection supervisor, holds two wafers, each of which contains many chips that end up in packages if they meet performance specifications. At left, Glenn Wagner, BAO product engineer, displays the photomask layout, which is essentially a greatly enlarged map of the memory chip.

Primary Theme Remains

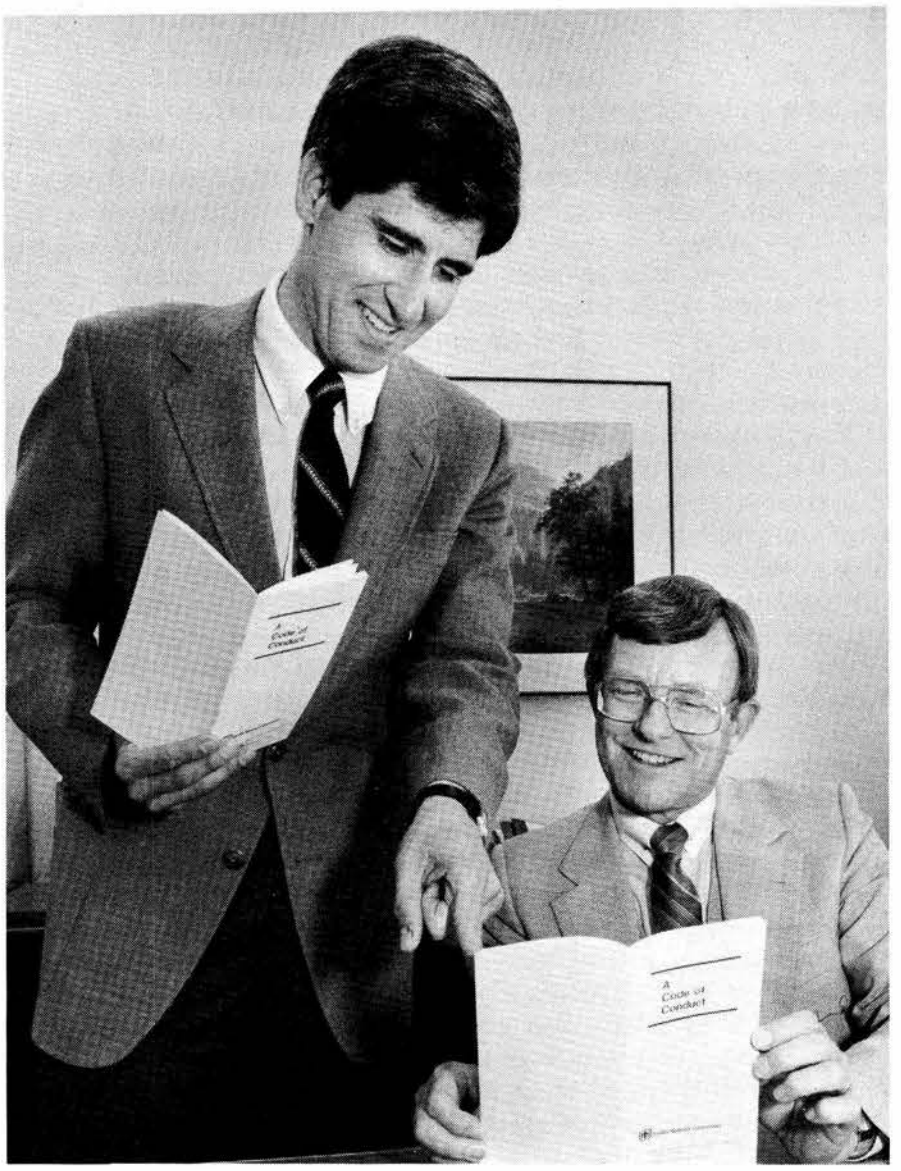
Code of Conduct Changes with the Times

All Sandians will soon receive the latest edition of the *Code of Conduct* booklet — "probably within the next couple of weeks," says Marv Torneby (3530), whose Personnel Department is responsible for the booklet's publication.

"The new Code is a comprehensive rewrite," continues Marv. "We began work on it last summer, and it reflects input from a large number of people at Sandia, including all the directors in 3000 and members of Small Staff, as well as Labs organizations most directly involved in the Code's guidelines."

"The Code is a dynamic, 'living' document," says Jay Sanchez (3533), Personnel and General Employment Division supervisor. "It changes with the times. That's why it's undergone revision every three or four years since it was first published in 1966." (The last revision was in 1984.)

The 1987 version presents a slightly different philosophy than previous editions. As always, it gives us some general guidelines for good corporate citizenship. But the new edition more clearly outlines what Sandia management expects from employees in terms of job-related activities and behavior.



THEY'RE SMILING because revision work on the *Code of Conduct* booklet is complete. Jay Sanchez (3533, left) and Marv Torneby (3530) have responsibility for publication of the booklet, which will be distributed soon to all employees.

High Expectations

"Those expectations are high because of our [Sandians'] unique responsibilities in national security and national defense," says EVP Orval Jones (20). "We all need reminders occasionally, so I encourage all employees to read the new Code of Conduct. It rightfully places a high priority on the way we conduct ourselves in carrying out Sandia's primary mission: the weaponization of nuclear explosives. Ensuring the safety and reliability of components and systems developed at the Labs is a major responsibility for all of us — individually and collectively. President Welber emphasizes that point in his message at the beginning of the booklet."

As Jay points out, the Code of Conduct mirrors societal changes. For instance, employees will note that the section on drugs and intoxicants is much more explicit; it makes clear that buying, selling, using, or possessing illegal drugs is prohibited by law and, therefore, these activities are prohibited both on *and* off the job. Following up on the Code's primary theme — that Sandians' on-the-job performance must be pretty much beyond reproach, since they're entrusted with jobs related to national security — it's pointed out that any use of drugs (including the misuse of prescribed substances) or alcohol that affects an employee's ability to perform his/her job will result in disciplinary action.

Signs of the Times

The booklet reflects other signs of the times with a couple of new sections: (1) smoking policy and (2) environment, safety, and health. "The section on smoking policy restates, essentially, the guidelines set by the medical organization two or three years ago," says Jay. "That is, that cooperation between smokers and non-smokers is expected, and that immediate supervisors should attempt to resolve differences among employees in a reasonable way."

The section on environment, safety, and health was added because a safe and healthful working environment for all employees is a primary management objective, according to Jay. "It's extremely important that employees report on-the-job hazards [to safety and health]," he says. "We hope this section of the Code will serve as a reminder for all Sandians to be on the lookout for hazardous situations."

Other changes appear as well. Employees — especially those who deal with the public on a continuing basis — are reminded that they should dress in an appropriate professional manner. And the expanded section on work time elaborates on loss of work time because of tardiness, abuse of established break and lunch periods, and unexcused absence. It all ties in with the Code's recurring theme: the Labs' dedication to accomplishing its mission with integrity and efficiency at a reasonable cost.

Protecting Government Property

There's increased emphasis on the importance of protecting government property, and the careful handling of company funds and credit cards. The section on conflict of interest contains more information on procedures for reporting interests in, and relationships with, suppliers — and tells employees whom to contact when questions arise in this area.

"As President Welber's message [in the Code booklet] states, Sandians are an exceptional group of people whose honesty and dedication are, collectively, beyond question," says Jay. "Witness the security investigation that each of us undergoes before receiving a clearance. However, sometimes questions arise as to what's appropriate conduct, given a set of circumstances. The Code of Conduct is a good source of answers.

"We want to make sure that each employee receives a copy of the booklet, and takes time to read it," Jay continues. "And if employees find any items in the Code that are not clear to them, I urge them to discuss those points with their supervisors."•PW

Retiree Picnic Set

Sandia Albuquerque's annual retiree picnic is May 21. Invitations will be mailed to all retirees and surviving spouses in mid-April.

THIS YEAR'S Secretarial Committee and the role of each member (from left): Paula Webb (3140), SWAPS (newsletter) chairperson; Estelle MacKenzie (5210/20), secretary; Goldie Piatt (6440), seminar chairperson; Elaine Howard (7110), SWAPS; Juanita Padilla (9240), SWAPS; Grace Sheldon (1110/30), vice-chairperson and historian; and Vicki Black (2310), chairperson.

Antojitos

Congratulations to the 40 Sandia engineers and scientists who entered the DMTS ranks this month. You've distinguished yourselves in an organization recognized for its talent. And thank you for helping our photographers get you properly recognized on these pages.

I've got to say this, June know? May you March proudly into the Sandia Hall of Fame and take your places in the August body. July? Not at all.

* * *

As You've Probably Already Discovered, a series of articles on Sandia's Center for Radiation-hardened Microelectronics (thanks, Rod Geer, 3161) occupies a good portion of this issue. On the national level, the CRM occupies only a tiny, highly specialized niche in the volatile semiconductor world. But it's an important niche -- lots of companies design and build semiconductors, some of them by the millions, but those chips aren't radiation-hardened. In the last decade, the CRM has worked to make sure that hardened versions of some highly advanced designs were available. Often the CRM has been the only source in the Free World for critically needed hardened parts.

When the definitive history of semiconductors appears, probably 50 years from now, the CRM's work should rate at least a footnote, perhaps a page. And it will be an interesting history, both in terms of the high-tech marvels the devices made commonplace and in terms of the people and companies who pioneered the avalanche of advances in semiconductor capabilities.

The CRM may not be the first Sandia mention in that history -- Willis Whitfield's (ret.) clean room invention will have to be there, whether or not the book's authors do a meticulous job. And former president George Dacey holds nine patents in transistors, the invention that preceded and made possible the workable semiconductor. Credit for the invention of the transistor in the late 40s rests firmly with three AT&T Bell Labs scientists: William Shockley, Walter Brattain, and John Bardeen. For making the vacuum tube obsolete and solid-state electronics a household word, they won the Nobel Prize in 1956.

But the transistor did not overcome the "tyranny of numbers," the Bell Labs term for the overwhelming number of parts and soldered connections necessary to build a complex electrical circuit. That's where Jack Kilby of Texas Instruments and Robert Noyce of Fairchild (then) come in. Working separately in the late 50s, they arrived at the concept of the "integrated circuit" about the same time. The IC puts all the parts of a circuit (resistor, capacitor, transistor, etc.) on one silicon chip so no separate parts -- and no soldered connections -- are necessary. (Both Kilby and Noyce are members of the National Inventors Hall of Fame.)

Along with the CRM, Sandia may rate another mention or two in a semiconductor chapter -- our strained-layer superlattice work, maybe; and former president Morgan Sparks holds 10 patents in semiconductors. If you think my list is wrong, call me -- in 50 years. •BH

* * *

"The thing I deplore most is the use of solid-state electronics by rock and roll musicians to raise the level of sound to where it is both painful and injurious." -- Nobel Prize Winner Walter Brattain

LAB NEWS

Published Fortnightly on Fridays

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Fun & Games

Bowling — Steve and Stephanie Guerra (guests) won the SANDOE 4-Game No Tap tournament held March 14-15 at Fiesta Lanes. Reyes (7474) and Trinie Chavez placed second. The next (and last) tournament is the Scotch Doubles at Fiesta Lanes on April 11-12.

* * *

Biking — "Breakaway" on the annual Multiple Sclerosis 150 Bike Tour on May 2-3. The tour starts from the Mountain View Inn at Tramway and Central and heads north to Glorieta. Participants and volunteers will spend the night in Glorieta at the Convention Center and make the return trip to Albuquerque the following day. Meals and lodging are included in the event. Participants collecting $2 or more per mile in pledges will be eligible for prizes including the grand prize, a free trip to Colorado for the Coors Classic Bike Race. To register or volunteer, stop by the LAB NEWS office for registration forms. For more information, contact the MS Society on 888-4418.

* * *

Running — The fourth annual 5K Library Fun Run, "Jog Your Mind, Run to Your Library," is set for April 11. The run starts at 9 a.m. at the UNM Law Library and ends at the Albuquerque Public Library downtown. Registration forms are available at sporting goods stores and public libraries. The Fun Run is sponsored by the Rio Grande Chapter of the Special Libraries Association.

* * *

More Running — "Run for a Purpose" is the theme of the 6th annual Lenny Marquez Run set for April 12 at 8 a.m. at Laguna Pueblo (meet at 7 a.m. at the Husky Truck Stop at I-40 and Coors). The 15.5-mile course ends at the Grotto of "Los Portales" in Seboyeta. A potluck picnic follows. For more information, contact Chuck Atencio (2832) on 247-8738.

Events Calendar

March 27-29 — "Fiddler on the Roof," Albuquerque Civic Light Opera presentation; 8:15 p.m., 2:15 p.m. Sun.; Popejoy Hall, 345-6377.

March 27-29 — New Mexico Hunter-Jumper Show, NM State Fairgrounds Horse Arena, 265-1791.

March 27-April 19 — "Lila Baal Jones," premiere play by Albuquerque playwright Grubb Graebner; 8 p.m. Fri.-Sat., 6 p.m. Sun.; Vortex Theatre (Central & Buena Vista), 247-8600.

March 27-July 31 — Exhibit, "Maya: The Image from the Western World"; 9 a.m.-4 p.m. Mon.-Fri., 10 a.m.-4 p.m. Sat.; main gallery, Maxwell Museum of Anthropology, 277-4404.

March 28 — Faux Arts Costume Ball, presented by New Mexico Repertory Theatre; movie memorabilia "mock-tion," palm reading, juggling, costume contests, face painting, dancing, puppet theatre, faux portraits, belly dancing, and music by the Broadway Elks; 9 p.m.-1 a.m., Dominic's Galeria at First Plaza, 256-3774.

March 28 — Jane Ira Bloom Quartet, presented by the New Mexico Jazz Workshop; 8 p.m., KiMo Theatre (tickets at Giant Ticketmaster outlets and BowWow Records), 842-6659.

March 28 — Fashion Workshop for Teens and Pre-Teens, presented by Emel & Modal Agency; 2:30-5 p.m., free, South Broadway Cultural Center, 848-1320.

March 28-April 7 — Pueblo Indian Museum sale: paintings, lithographs, prints, woven textiles, pueblo pottery including Casas Grandes (all are museum storage excess and/or duplications); 9 a.m.-5:30 p.m. Mon.-Sat., Indian Pueblo Cultural Center, 843-7270.

March 29 — Concert, "Desert Aires: New Mexico Composers," New Mexico Symphony Orchestra Sinfonietta, in honor of New Mexico Diamond Jubilee; 3 p.m., Simms Auditorium, Albuquerque Academy, 842-8565.

March 29 — Concert, Albuquerque Philharmonia Orchestra, conducted by Willie Sucre, featuring music by Mozart, Franck, and Borodin; 3 p.m., KiMo Theatre, free.

March 29 — Movietime at the KiMo Series: "The Man in the White Suit," starring Alec Guinness; 7 p.m., KiMo Theatre, 848-1374.

April 1 — Central New Mexico Audubon Society Nature and Wildlife Film Series: "Autumn Journey to Alaska," presented and narrated by Thomas Sterling; 7:30 p.m., Popejoy Hall, 881-9387 or 255-0307.

April 1-12 — "The Real Thing," New Mexico Repertory Theatre presentation of Tom Stoppard play; 8 p.m. (2 p.m. Sat. & Sun. matinees), KiMo Theatre, 243-4500.

April 4-May 17 — MA/MFA Exhibition, annual event showcasing work by UNM graduate art students; Upper West and Van Deren Coke galleries at UNM Art Museum, 277-4001.

April 4-May 17 — Exhibit, "Lucy Maki Paintings"; 10 a.m.-5 p.m. Tues.-Fri., 1-5 p.m. Sat.-Sun. (opening reception, April 3, 5-7 p.m.); Jonson Gallery, UNM, 277-4967.

April 5 — Fine Arts Music Series: "LaSalle String Quartet," quartet-in-residence at the University of Cincinnati College-Conservatory of Music; 4 p.m., First United Methodist Church (4th & Lead), 243-5646.

Old Lotus Blooms on Raceway

Joel Lipkin (8316) has found a good use for a 20-year-old sports car that other owners might be trying to sell — turn it into a vintage racer and compete at Sears Point and Laguna Seca raceways.

He became interested in auto racing while he was in college, but he was too poor to own a sports car at the time. Finally, in 1972, three years after he began work as a mechanical engineer at Sandia Albuquerque, Joel modified a Lotus Ford Cortina sedan for road racing and began competing on tracks at Ft. Sumner and Roswell, N.M., as well as La Junta, Colo., and Dallas.

After he totaled his car against a temporary restraining wall in 1978, Joel cooled on racing. But, in 1984, after moving to Livermore, his interest was rekindled. He began by competing in autocross events: Drivers follow a winding course defined by traffic pylons in a parking lot — a familiar sight at the Alameda County fairgrounds in Pleasanton.

But autocross isn't racing. To get back on track, it took a birthday — that of Joel's 1967 Lotus Elan (which he's owned for 16 years). When it turned 20 last year, it was qualified for vintage racing. And Joel was ready to resume racing.

The attraction of the sport? "It brings out the mechanic in me," says Joel. "I love to tinker with cars to make them run better.

"And I enjoy the competition," he continues. "Few things are more exciting than taking a car you've improved and competing one-on-one in a race with other drivers." His competition in the vintage medium-production class includes brand names like Ferrari, Porsche, and Jaguar — "not easy cars to beat," he notes.

AHEAD ON THE TRACK at Sears Point is Car No. 5 with Joel at the wheel.

Twenty-Minute Sprint

A typical race is actually a sprint from start to finish — it is only 12 laps long and takes about 20 minutes. Average speeds are about 70 mph, but the maximum speed on the straightaway is more than 90 mph.

There is no profit motive in this class of racing, Joel explains. Registration for an event is $100. Then there are the costs of towing the car to and from the track, living expenses for the weekend, and, of course, the parts and tires needed to keep the car in top shape. Gas costs are higher than normal too, because he mixes regular leaded gasoline with aviation fuel to get the desired higher octane for better performance on the track. As Joel puts it, "You only spend, spend, spend."

Joel does get double duty out of his Lotus. He puts the soft top back on, peels off the racing number decal, and uses the car around the Valley during the week. Or farther — he's a member of the Golden Gate Lotus Club, so he's in touch with some 200 other enthusiasts in the Bay Area who hold outings and social events.

TAKING A BREAK between races is Joel Lipkin (8316) beside his Lotus Elan, No. 5.

And what does he do during the off season? Skiing and bicycling. He prefers long skiing trips to Utah, Colorado, and Canada. Joel's biking is equally intense, some 3000 miles a year — considerably more than he does on the race track.

At first glance, biking and skiing may not seem compatible with Joel's racing interests, but Joel thinks they all complement each other: "Bicycling helps keep me fit for skiing, and skiing really sharpens the reflexes and concentration I need for track competition."

SANDIA LIVERMORE NEWS

VOL. 39, NO. 6 SANDIA NATIONAL LABORATORIES MARCH 27, 1987

Sympathy

To Mike Birnbaum (8242) on the death of his mother in New York City, Feb. 27.

To Lorraine Eldridge (8474) on the death of her sister in Kealakekua, Hawaii, Feb. 27.

To Glenda Padilla (8272) on the death of her father in Oakland, March 3.

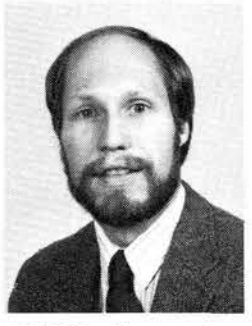
To Mike Firneno (8024) on the death of his grandmother in Manteca, March 5.

Relativity Conundrum on a Plane

Midnight caught me as I crossed the International Date Line. Instead of putting my watch back one hour, as had been the case on crossing each time zone during my westward trip, here I jumped forward 23 hours as I left the left-hand edge of the map and reappeared on the right. In that instant, the front half of the plane was 24 hours late relative to the back. I was earlier than the pilot, who was in front of me and heading forward.

Frank Close, *New Scientist*

Supervisory Appointment



BOB LUCHT to supervisor of Reacting Flow Division 8351, effective March 16.

Bob joined Sandia Livermore's Combustion Technology Department in February 1983; he first worked on Coherent Antistokes Raman Scattering (CARS) diagnostics of coal-particle-laden flames. For the past two years, he has used CARS to measure temperatures in internal combustion engines.

Bob earned a BS degree in nuclear engineering and a PhD in mechanical engineering, both at Purdue University.

His outside interests include running, skiing, tennis, and golf. He is also active in the Optical Society of America, the Society of Automotive Engineers, and the Combustion Institute. A native of Kent, Ohio, Bob now lives in Dublin.

Take Note

Rick Wayne (8400) was honored as Business Associate of the Year by the Livermore Valley Charter Chapter of the American Business Women's Association during its February meeting. Rick was nominated by his secretary, Arline Harrell (8400), and selected by a panel of three judges outside the chapter. Arline is vice-president of the local ABWA.

Changing of the Guard

You could rent a three-bedroom house (with fireplace) on the Base for $71, plus utilities. A Coke was a nickel; cigarettes, 20 cents a pack. You could fill your gas tank for well under $5. Hamburger was 39 cents a pound.

It was 1950, and the nation was more than a little concerned about our atomic secrets ending up in Russian hands. Military police guarded the newly formed Sandia Corporation — sometimes a little too zealously, many felt. It was time for the Corporation (as it was widely known then) to have its own guard force. After interviews with more than 1000 men, 150 were hired as Sandia's first security inspectors.

The last four of that original group — Ed Sims, Bob Stewart, Verne Honeyfield, and Ted Varoz (all 3435) — have retired within the past two years, with Ted the last one out the gate at the end of December.

Last Four Remember Well

With 36-1/4 years of service, Ted had the most seniority. Just after the war he had been a cattle inspector with the U.S. Department of Agriculture. "I came back to Albuquerque looking for a job and ran into my old high school coach," Ted says. "He knew about the guard force, and since I'd been in sports in high school, he thought it might do me some good, so I came out and applied.

"I'll never forget," he says, "our starting pay was $1.46 an hour."

Ed Sims, with just 1-1/2 years less service than Ted, had spent more time around Kirtland than most people. He was stationed here during World War II.

"This place where we are right now was called Oxnard Field," Ed says. "Then it became ADTS — Albuquerque Depot Training Station. When I went overseas, I'd never heard of Sandia.

"We used to sit over at Kirtland with binoculars and watch them bore those tunnels in the Manzanos," he continues. "We didn't know what they were doing."

The year before he was hired as a security inspector, Ed worked as a carpenter, helping build the Coronado Club. "It was the first club built for civilians on a military base. We finished it in April of '49. [Ed. note: Too early, maybe '50?] Inspectors came from Washington — about eight of them, I think. It was really a big deal."

He was also the first to swim in the Club's pool. "It was April, and we nearly froze to death. But we said we were going to do it, so we filled it right up and jumped in."

Bob Stewart was also stationed at Kirtland during the war. Later, he was working at Coca-Cola when he heard that Sandia was forming its own guard force. He heard about the job from a friend who was a milkman.

Verne Honeyfield was a cross-country bus driver when he heard about the job. His wife worked with another woman whose husband was an MP on the Base. He told his wife about the guard force, and she told Verne's wife. "I wasn't really happy with my job at the time — I didn't like being gone for long periods of time — so I came out to check," Verne says.

Verne almost missed the chance to work here because the telegram notifying him he'd been hired was sent to the wrong address. "I just happened to call out here," he says, "and they told me they'd sent the wire a month ago."

Guard Force — In Force

The men began their training in September 1950 after getting cleared by the FBI.

"I liked the job right from the start, from the work standpoint," Bob says. "Working in logging camps, which is what I did right after the war, isn't the easiest job in the world. We were so new — we all had to feel our way along.

"Before we were cleared, we were responsible for material control and worked with an MP who checked badges," he continues. "I don't think the MPs treated people very well — public relations didn't mean much to them."

"Our trainers tried to prepare us mentally for what we were going to do," Verne adds. "We enforced the rules, but we tried to do it with a little courtesy and finesse."

"We had to learn how to deal with people — the irate citizens, for example — who wouldn't surrender their badges," Bob continues. "But if you handle people properly, they're nice, too."

They were beginning a tradition.

WALLET PHOTO of the days gone by belongs to Art Jimenez (3424). The recently found photo was taken in 1948, when he was in the 8450th MP group, the security force for Areas I and II. After a stint in Korea, Art came to work for Sandia and is now nearing 35 years of service.

Changes Since the 50s

All the men agree that things have changed a great deal in the past 30-odd years.

"It was stricter then," Ted says. "We had to have our hair cut and be shaved according to Security specifications. About two months after I started working here, I said to myself, 'Oh my gosh. I just came out of the Army, and I'm back in the Army again.' "

"There was definitely more regimentation then," Verne continues. "Everybody wore the same hat, the same coat."

"You had to be dressed identically at the gates," Ted says. "If I wore a jacket, the other guy had to wear a jacket. If he could stand the cold and didn't wear a jacket, I had to do the same. It's more — what would you call it? — *human* now. I don't know whether that's good or bad. . . ."

"There weren't more than six permanent buildings when we were hired," Ed says. "The other buildings were all temporary and storage was all out in the open. It didn't matter if it was toilet paper or brushes — everything was in cardboard boxes, covered with a tarp."

Their old headquarters was in Building 815 and the main gate was by Building 824. "Old Gate 3 is still there, but it's welded shut," Bob says. Bldg. 802 was under construction at the time they were hired. There were no paved streets then, and the guard shacks were made out of wood.

"Our little old gate shacks left a lot to be desired," Bob continues, "and our drinking water was in canvas bags."

"You'd take a drink of water and get about three feet of yarn down your throat," Ed confirms.

"Then we had gallon picnic jugs filled with ice water," Bob continues. "The man on post relief had to fill them in the basement and carry them upstairs. You always helped because you knew your time was coming. The gate shacks had no bathrooms and no air conditioning, but there were little electric heaters for warmth in the winter."

"The guard shack at Gate 6 had a coal stove in

(Continued on Next Page)

Memories of Security Management

Wanted, Found: Neighborhood Cops

Years ago — about 35, actually — if you came to work above and beyond normal working hours, you were confronted by an MP who shouted, "Halt!" You had to get out of your car, place your badge on one of the fenders, and walk five paces in front of the car. The MP was supposed to satisfy himself beyond a reasonable doubt that you were indeed a person who had access to the base. Quite a problem for a sometimes-absent-minded scientist.

Then there was also the problem of materials leaving the base without authorization. Sometimes it was accidental; other times it was theft.

In 1950, Sandia management decided to solve both problems by forming its own guard force — called security inspectors even today.

Hal Gunn (ret.) was working in Purchasing when he was asked to form this new group. Hal first hired Charles (Buck) Weaver, who worked in security for the AEC (Atomic Energy Commission).

"Buck and I interviewed more than 1000 people and hired 150 of them," Hal says. "The men had to be in their late twenties to early thirties. Although we were looking for men with some time in the military or some police experience, we didn't want the military-police type. We were looking for 'neighborhood cops.'

Formula to Fit

"There were five or six thousand employees [Ed. note: more like two or three thousand in 1950] at Sandia at the time, and it wasn't pleasant to institute property controls," Hal continues. "We needed men who were intelligent, pleasant, friendly, and handsome. That first group we hired were a fine crew of people. They had to treat the employees courteously and tactfully."

After they were hired, the men had to be completely outfitted with uniforms and equipment — all bought locally. Hal contacted all suppliers personally. "I had to buy everything from whistles and chains to uniforms, which were tailor-made. The original uniforms were attractive: campaign-style jackets, shirts, slacks, and Stetson hats, all in a tannish beige."

When Clearance Took Two Months

"We organized the group on a military pattern with lieutenants supervising a group of men. There was some military discipline," Hal says. "Now we had our people, and we had them dressed. Then we had to wait for Q-clearances, which took two to three months," he continues. In the meantime, the men were kept busy with patrols outside the fences at night — and with orientation. "The buildings at the time were ramshackle wooden barracks, so the fire hazard was real," he says.

"Our next chore was writing the training manual," Hal continues. Buck Weaver and Hal wrote the manual; and Buck, Hal, and Stan Tarnowsky (a former New York City policeman) taught the classes.

"It was a difficult task," Hal says. "The AEC insisted on stern measures for people dealing carelessly with classified material, but Western Electric wanted no stern measures used. We tried to satisfy both organizations, and we used Western Electric experience in protecting people and property.

"This was a very sensitive time," he continues. "The Rosenbergs had been on trial, and Klaus Fuchs had stolen nuclear secrets from Los Alamos. We couldn't even disclose the number of people working at Sandia."

Fences protected Tech Areas I and II and Manzano then, as now. "Our first job was to man the gates to the areas and inspect badges," Hal explains. "Our second job was to write up a property pass system to reduce the theft of tools and equipment. The idea of property passes had to be accepted by the people. That meant that the guards had to be tactful in enforcement and do it in a nice way."

'Shaking the Safes'

Every night the guards patrolled the buildings, "shaking the safes," as Hal calls it. "There were thousands of safes with millions of classified documents in them, and every night the guards would find three or four safes open. The guards would leave a 'Hairy Hand' notice in the safes that were open: 'The Hairy Hand has been here. Please report to the security office.' "

The offenders would report to either Hal or Buck, who would give them a five-minute lecture on the importance of respecting security measures. "All types were guilty from clerks to top engineers. I think the engineers were worst," says Hal.

Hal and Buck were, in a sense, blazing new trails with the new guard force. "We had to have the right kind of people, and I think we found them," he says.

(Continued from Preceding Page)

Changing of Guard

it," Ed adds.

In the old days, if the men had a nature call, they called the gate switchboard on EE8A field phones. "You'd crank the handle, just like on the old-time phones, and then someone would come out to relieve you — so you could relieve yourself," Bob says.

"We had Detex clocks at certain points on the base," he continues. "As we patrolled, we had to put a key in and twist it. It would register on paper. Then at least they knew we'd been there."

"In the beginning, they told us we had to punch those clocks every 15 minutes," Ted says. "I guess I misunderstood. I thought we had to cover the whole area in 15 minutes, and I was running back and forth trying to make the whole area in that 15 minutes. When they found out, they cracked up. Somebody said, 'Oh, no, Teddy. It's one clock every 15 minutes.' "

Ted isn't the only one with an amusing story. Bob tells the story of the runaway bicycle.

"It was the swing shift and I was on the old North gate. There was a bicycle parked at the gate. This guy — I won't mention his name because his wife still works here — jumped on the bike and took off toward 815. He was really 'makin' knots.' He raced up to the door and hit the brakes. But there were no brakes. He rode right through the door and ran into the communicator's desk. The bicycle stopped, but the guy went right over the handlebars — right into the communicator's lap."

"One night I was on graveyard," Verne says. "There were only two vehicles moving out here, and they had a wreck. Only two vehicles in the same area, and they collided!"

Ed remembers an incident in the early days that took place in the escort shack. "Back then you had to wear your hat even in the escort shack," Ed says. "We were sitting around waiting to escort somebody, and Stuart Breeding had his hat off. The sergeant, Digger Dance, came in and told him to put his hat back on. Breeding did but took it off as soon as Digger left. Digger came back and again told him to put the hat back on. As soon as Digger left, off came the hat. The third time, Digger just took the hat and jammed it on Breeding's head down over his ears. Meanwhile, Charlie Graves was logging trucks in. He thought Digger had left and said, 'Well, you old s.o.b., seein' as you're gone, I think I'll take my hat off.' And he did. But then he looked up and saw Digger standing there and without batting an eye, he said, 'and seein' as you're back, I'll put it right back on,' and kept right on logging. I just rolled on the floor."

Yes, things have changed in the past 36 years. "Now the guard shacks are really uptown," Bob says. "There are bathrooms, hot and cold running water, air conditioning, and little roofs."

Now there are women security inspectors, and Ed finds that change a very positive one. "Of course, I'm kind of prejudiced," he says. "My daughter Colleen has been on the force for five years."

The tradition continues.

[Ed. note: These articles were written by Sharon Ball, former LAB NEWS summer staffer.]

EARLY MPs at Sandia size up vulnerable points on a police silhouette target.

Distinguished Members of Technical Staff — DMTSs

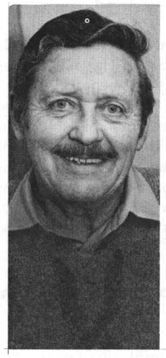
40 More Sandians Honored

Forty new names were added this month to the list of Sandia's Distinguished Members of Technical Staff. The new honorees bring the total to 173 named to the DMTS roll.

The program began in March 1983; more DMTSs were named in December 1983 and May 1985. Each DMTS receives a plaque containing the information next to the appropriate photo on these pages, a pin, and $1500 during a presentation by the employee's vice-president.

The DMTS program honors those employees who have sustained outstanding performance or made a unique contribution to the technical missions of the Labs. All non-supervisory members of the technical staff with 10 or more years of professional experience are eligible. The total number of awards is limited to approximately 10 percent of the non-supervisory MTS population.

Of the 133 prior DMTS honorees, 15 have been promoted to supervisor, one has been reclassified to Member of Management Staff, and 15 have retired or left Sandia.



Arthur Mullendore (1831)

For his contributions in the development, processing, and characterization of materials for use in extreme environments. His consistent outstanding performance has resulted in a greater understanding of the materials limitations imposed on the design of space nuclear reactors, advanced reentry vehicles, and magnetic confinement fusion reactors.

William Abel (2534)

For his continued contributions to Sandia's component development programs. His technical insight and program management skills have produced critical component designs that have resulted in new weapon performance capabilities.

Robert Blewer (2147)

For his contributions to advancing refractory metal technology for integrated circuits, both in industry and in Sandia programs, to the development of a long-life neutron generator concept, and to advances in thin-film characterization using ion implantation techniques.

Sam Martin (2541)

For his continued outstanding contributions to Sandia's programs. His broad-based technical skills, combined with dedicated and unselfish effort, have made and continue to make major contributions toward the solution of our national problems.

Herman Stein (1111)

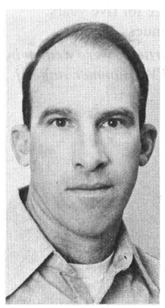
For his outstanding contributions to the fundamental understanding of defects and radiation effects in semiconductors, insulators, semiconductor electronics, and for pioneering work on ion implantation.

Lawrence Posey (2321)

For his sustained contributions to Sandia's weapon-development and nuclear-effects testing programs. His ingenuity, technical leadership, and dedication to excellence have allowed him to make major contributions to the success of Sandia's nuclear-effects testing capability and weapon subsystem radiation-hardness evaluation and verification programs.

Dennis Ghiglia (2643)

For his superlative technical and project leadership in the development of the Image Processing Facility, and its applications to a full spectrum of projects of Laboratories and national importance.



Paul Mix (1264)

For his consistent excellence in pioneering experiments on the dynamics of intense electron and ion beams, the development of beam diagnostics, and the study of hydrodynamics in beam-driven systems.

Charles Vittitoe (2322)

For his distinguished contributions to the numerical modeling and analysis of the nuclear electromagnetic pulse, of EMP interaction with weapons systems, and of associated electromagnetic phenomena and threats to national security and to energy sufficiency.

Roy Lanes (5143)

For his consistently outstanding contributions to experimental reentry vehicle programs conducted in support of advanced development activities at the Laboratories. His instrumentation system designs reflect creativity and deep insight into the behavior of test vehicles.

Fred Blottner (1556)

For his major contributions to computational fluid dynamics and heat transfer. He has demonstrated unique fundamental understanding and meticulous research in viscous flows, gas dynamics, chemically reacting flows, and laser welding, all of which contribute to the weapon and energy programs of the Laboratories.

Harry Fisher Jr. (5145)

For his continued contributions to flight telemetry system development for nuclear weapon stockpile evaluations that have led to the establishment of new instrumentation concepts. His insight, leadership, and project management have guided and continue to guide Joint Test Assembly principles and electronic design at Sandia.

Bob Alvis (5153)

For his continuing contributions to both energy and weapons programs. His combination of technical competence and project management skills have greatly enhanced the success of programs in both areas.

Jerry Cuderman (5160)

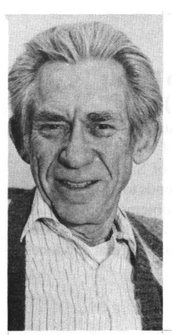
For his sustained contributions to the advancement of Sandia's work in atomic physics, laser fusion research, underground nuclear testing, gas well stimulation, and nuclear weapon applied research. His technical understanding, insights, and organizational skill have been instrumental in advancing our progress in solving a variety of major technical problems.

Bill Patterson (5165)

For his sustained contributions in terradynamics, earth penetrator applications, and advanced nuclear weapon systems. His technical insights, design innovations, and system integration skills have been instrumental in advancing our ability to implement new weapons applications.

Paul Souder (5220)

For his extensive contributions to the U.S. nuclear weapons program and especially for his particular work over the years in the use of these weapons and related activities.

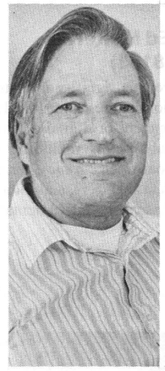


Stan Howard (5233)

For his outstanding technical contributions to the design and development of nuclear handling and storage equipment, including the mechanical design of the weapon storage vault of the Weapon Storage and Security System.

Frederick Luetters (5234)

For his outstanding program management skills, technical contributions, and international representation of the Laboratories, including accomplishments in Emergency Management Information System development, NATO Intrusion System development, and DOE Transportation System evaluation.

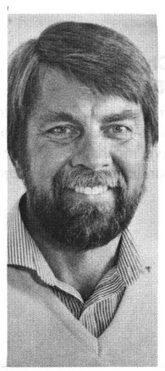


Duane Arlowe (5261)

For his many varied and significant contributions in the innovation of concepts and the application of state-of-the-art technology. Throughout his career, he has consistently developed and implemented creative engineering solutions in the areas of nuclear safeguards, development testing, field instrumentation, and battlefield robotics.

Daniel Aeschliman (6201)

For his contributions in the characterization of reentry-type gas flows and in energy. His consistent outstanding performance has included diagnostics and characterization of plasma flows and experimental verification of complex heat and mass flow mechanisms in long cylindrical annular passages.

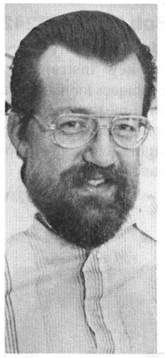


Paul Klimas (6225)

For his sustained outstanding contributions in the areas of aerodynamics research and wind energy technology development at the Laboratories. Of particular note are his innovative research and leadership skills demonstrated in his involvement with the Vertical Axis Wind Turbine (VAWT) program.

Aldred Stevens (6313)

For his many contributions to complex problems in shock wave dynamics, oil shale technology, and nuclear waste management. His combination of strong technical capabilities with an ability to coordinate and direct new areas of investigation has allowed him to make major contributions to the solution of national problems.



Randy Cole (6418)

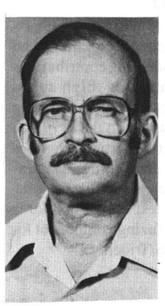
For his sustained outstanding performance and contributions to weapons effects and reactor safety research through the development and application of computational methods, and the transfer of his technical knowledge to other research scientists.

David Williams (6419)

For his sustained excellence in the analysis of nuclear systems safety and for outstanding technical contributions to the Laboratories' reactor safety research programs.

Margaret Chu (6512)

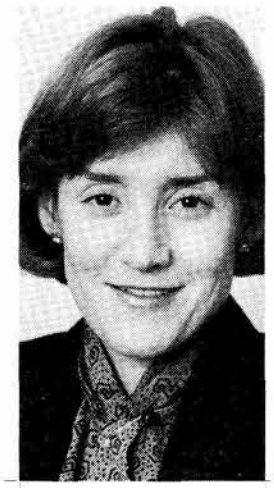
For her sustained outstanding technical contributions in performance assessment of nuclear waste repositories.



Kenneth Glibert (7112)

For his many contributions to the X-ray diagnostic measurements of nuclear weapons detonations and laboratory radiation sources.

DMTSs

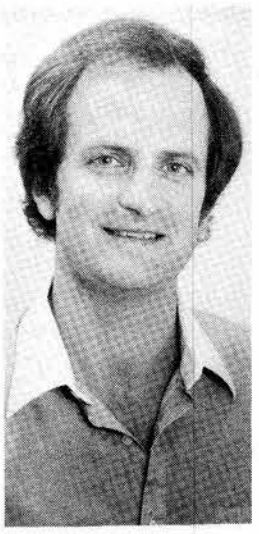


Kathleen Diegert (7223)

For her significant contributions to nuclear weapons development and production through the innovative use of statistical ideas and methods to resolve complex questions. Her skills and diligence have led to improved understanding of important development and production processes.

Len Dighton (8151)

For his significant contributions in the design and development of warhead and bomb electrical systems including those for the W58, W70, W71, B77, and B83.



Charles Jakowatz (9115)

For his sustained outstanding technical contributions to a variety of Sandia programs. He combines expertise in stochastic analysis with an exceptional ability to creatively apply it to diverse problems in signal processing and analysis.

Bob Moyer (7242)

For his ingenuity in developing new instruments and techniques for making microwave measurements and his competence in calibrating high-accuracy microwave standards.

Ed McKelvey (8153)

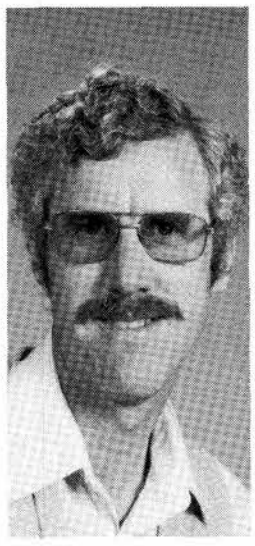
For his significant contributions in the design and development of digital electronic subsystems including use-control electronics, terminal data analyzers, and Joint Test Assembly instrumentation.

Michael Forrestal (9122)

For his significant contributions in mechanical sciences for weapons applications. His analytical models and experiments provide a fundamental understanding for impulse-loaded structures and penetration mechanics.

Jim Ridinger (7261)

For his pursuit of thoroughness and realism in weapons evaluation in general and his contributions to the evaluation program for the various mods of the B61 in specific.



Carl Melius (8357)

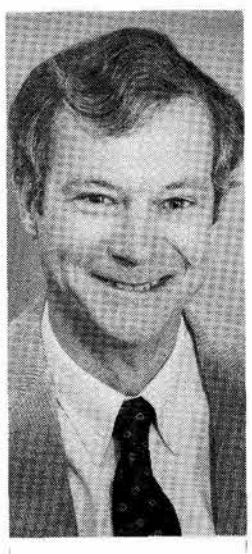
For his outstanding contributions to Sandia's weapons, energy, and reimbursable programs. These contributions have led to important extensions of the Laboratories' capabilities in its mission of supporting national defense. Also, for his achieving international recognition as a theoretical chemist whose developments in modern theoretical thermochemistry have expanded greatly our understanding of gas-phase chemistry.

Lawton Miller (9142)

For his sustained contributions to programs that have established Sandia in a preeminent position in reentry vehicle technology and flight tests. His achievements have been significant in the areas of strategic offense and defense.

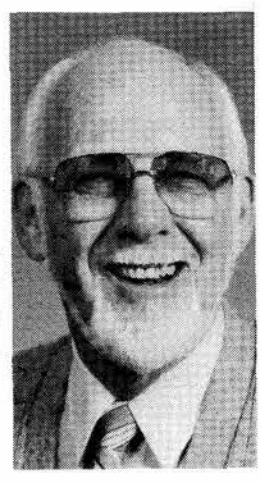
Howard McCollister (7471)

For his significant contributions to nuclear weapons development through innovations in glass science. His insight and creativity in the development of a high-strength insulator material ("S" glass-ceramic) have opened up a whole new era in glass seal technology with the utilization of super alloys in weapon components.



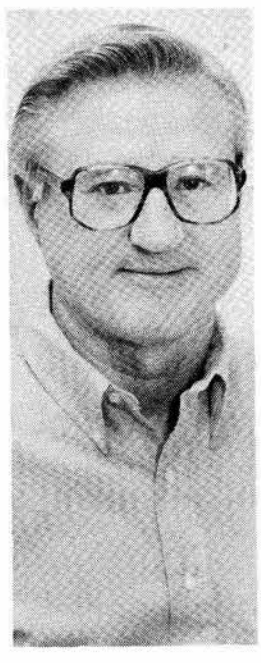
Bob Fellerhoff (9143)

For his significant contributions to the mission of the Laboratories, including the design of a high-velocity rocket system for rain erosion studies, a successful artillery shell recovery system, the SWERVE reentry vehicles, and a mortar-delivered intrusion detection system.



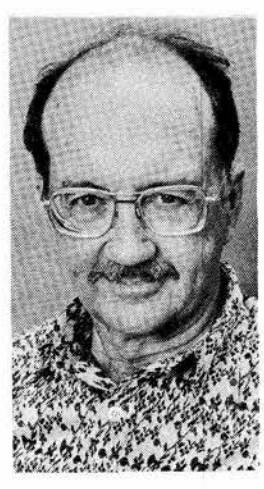
Chuck Pignolet (8434)

For his significant contributions in creative and innovative mechanical design for Sandia engineering projects.



James Kannolt (7545)

For his expertise in engineering rotating equipment and his outstanding contributions in developing high-speed spinners for product testing associated with the W79 and W82 artillery shell programs and in developing an ultra-precision centrifuge to provide a test capability for a critical fuzing component for the W88/Trident II.



Glenn Elliott (9212)

For his sustained outstanding technical contributions to a number of Sandia missions. He responds to difficult technical problems with a leadership ability and a design approach that produces results.

Take Note

Crawford MacCallum's (1271) work with AT&T Bell Labs physicist Marvin Leventhal (LAB NEWS, Dec. 5, 1986) was mentioned briefly in the March 23 TIME cover article, "Supernova!"

* * *

As part of an effort to begin a Habitat affiliate in Albuquerque, Millard Fuller, founder of Habitat for Humanity, will speak at 7 p.m. on April 2 at First Presbyterian Church (I-25 & Grand). Habitat builds low-cost houses for the poor at no profit, without interest charges, and with no government funding in 170 cities in the U.S. and 16 foreign countries. For more information, contact Bob Paulsen (9014) on 6-0153.

* * *

The 15th Annual Los Novicios Craft Guild Spring Craft Show is April 3-5 at Montgomery Plaza Mall. Proceeds go to the Albuquerque Christian Children's Home. For more information, contact Alva Moriarty on 892-9551 or Marge Hartmann on 821-7079.

* * *

"Recent Trends in the Evaluation of Fringe Science," was the topic of Ken Frazier's (3161) talk, sponsored by the Southern California Skeptics and the Caltech Y, at the Caltech campus on March 8. Ken appeared in his capacity as editor of *The Skeptical Inquirer*, the quarterly journal of the Committee for the Scientific Investigation of Claims of the Paranormal (CSICOP). How to tell the difference between responsible speculative science and pseudoscience was one subject Ken discussed.

* * *

Dick Monahan's (2631) daughter Leanne was recently selected from 9000 applicants as one of the 510 young people to join "Up With People," the international, educational, and cultural program that encourages worldwide understanding among people.

* * *

Retiring this month and not shown in LAB NEWS photos: Pat DiDomenico (154), Dale Fastle (7556), Jean Schuster (150), Richard Willey (1128), and Vivian Wuttke (7473).

volunteers in action

Here are some current volunteer opportunities for employees, retirees, and family members. If you would like more information, call Karen Shane (3163) on 4-3268.

MONTEZUMA ELEMENTARY SCHOOL would like a Sandian to present a show-and-tell project to youngsters in grades kindergarten through 5 at a student assembly (10:30-11:15) on Friday, May 1. A scientist or engineer who could do a bells-and-whistles-type demonstration (using lasers, chemicals, gadgets, or whatever) to teach as well as hold the students' interest would be very much appreciated.

WESTERN FOUNDATION OF RAPTOR CONSERVATION needs help in monitoring bird of prey migration along the north-south ridges of the Sandia Mountains. The information obtained will be used as an index to changes in population over a long period. No experience is required. Weekday and weekend volunteers are needed who also like to hike—it's approximately two miles and a 1000-ft. gain in elevation to the monitoring site on the south face of the Sandias.

NEW MEXICO WING, CIVIL AIR PATROL, a volunteer organization, is an official auxiliary of the United States Air Force. Last year, the New Mexico Wing tied for third in the nation in the number of lives saved through emergency services activities, which include search and rescue for missing hikers and hunters in support of the NM State Police, search and rescue for missing aircraft, and emergency transportation of medical supplies to outlying communities. CAP is currently recruiting pilots to fly its aircraft during searches, teenagers for its cadet program, and ground support members for searches, communications, education, and training.

UNM's MENTAL HEALTH/MENTAL RETARDATION CENTER is looking for a couple of staff persons to help at its auxiliary thrift shop from 10:30 a.m. to 2 p.m. on Thursdays (each volunteer would work only every other Thursday). This very informal shop provides goodwill to staff and clients. As part of therapeutic activity, patients visit the shop and select a couple of clothing items, compliments of the auxiliary.

EQUAL EMPLOYMENT OPPORTUNITY AND AFFIRMATIVE ACTION

Sandia National Laboratories

Policy Statements

INTRODUCTION

Policy Statements

The following statements reflect Sandia National Laboratories' policies regarding

- Equal Employment Opportunity and Affirmative Action (EEO/AA)
- Sexual Harassment, and
- the Handicapped and Veterans.

Purpose

I am issuing these statements

- to reaffirm the Laboratories' commitment to the principles of Equal Employment Opportunity and Affirmative Action, and
- to engage the support of all Sandians in fully implementing our policies.

EEO/AA

EEO Policy

Sandia will continue to conduct corporate activities in accordance with EEO federal and state laws and regulations without regard to

- race
- color
- national origin
- religion, or
- sex.

Sandia will also comply with the laws and regulations concerning

- age
- physical or mental handicaps
- disabled and special disabled veterans, and
- Vietnam era veterans.

EEO Areas of Application

Sandia's EEO policy applies to the following activities:

- recruiting
- compensation
- benefits and services
- training
- advancement
- promotion
- transfer
- termination.

We ensure that employment, employee selection, and promotion decisions are in accordance with the principles of equal opportunity by imposing only valid requirements.

Compliance with the Spirit of the Law

It is Laboratories policy not only to comply with the letter of the laws and regulations of federal and state governments, but to practice the true spirit of equal employment opportunity.

AA Definition

Affirmative Action is taking positive steps to hire and promote women and minorities to achieve a representation at Sandia equal to their presence in the applicable workforce.

EEO Complaints

It is the policy of Sandia National Laboratories to endeavor to handle internally any employment or work-related complaint alleging unlawful employment acts or practices. Any employee who has an EEO-related complaint should

- discuss the matter with immediate supervision
- contact the Personnel Representative, or
- contact staff in Sandia's EEO/AA Dept. 3510.

All complaints will be investigated, and the EEO organization will inform complainants of their rights and available options.

AA Progress

Sandia's affirmative action program has produced positive results which are reflected by

- greater numbers of women and minorities on roll
- national recognition of the handicapped program, and
- a positive corporate image in the community.

AA Commitment

Sandia will continue to concentrate on advancing and promoting qualified women and minorities into higher job classifications, supervision, and management.

Employee Responsibility

Employees - I expect all employees to foster a work environment that is free from discrimination and is supportive of female, minority, and handicapped employees to allow all employees to reach their full potential.

Supervisors - I expect all supervisors to be familiar with the Affirmative Action Plan (AAP), to discuss it with their employees, and to take an active, positive role in fulfilling our EEO commitment.

Vice Presidents - I expect all Vice Presidents to take the lead in implementing Sandia's AAP.

Personnel Director - The Director of Personnel, R. C. Bonner, and staff will continue to monitor all equal employment opportunity activities and report to me on the effectiveness of our AAP, including recommendations for necessary action to ensure attainment of our objectives.

Objective

Optimum use of our human resources is the ultimate objective towards which we continue to strive.

SEXUAL HARASSMENT

Sexual Harassment Policy

It is against Sandia policy for any employee to harass another employee, and any conduct which creates an intimidating, hostile or offensive working environment is absolutely prohibited.

Prohibitions

Examples of prohibited conduct include:

- making unwelcome sexual advances
- making unwelcome requests for sexual favors
- engaging in verbal or physical conduct of a sexual nature
- displaying any pictures or objects of a sexual nature.

Furthermore, no supervisor (or other employee responsible for work assignments) shall threaten or insinuate that an employee's submission to or rejection of sexual advances or requests for sexual favors will either enhance or adversely affect any terms or conditions of employment or career development.

Harassment Complaints

Any employee who has a complaint of sexual harassment should

- report such conduct to immediate supervision or management, or
- seek the assistance of any of the staff of the
  - EEO/Affirmative Action Dept. 3510, or
  - Benefits, Medical, and EEO Div. 8026.

An investigation of all complaints will be undertaken immediately.

Harassment Sanctions

When an investigation confirms a complaint about an employee or agent, that person will be subject to appropriate sanctions ranging from a warning up to and including termination. Supervisors who fail to promptly take appropriate action regarding instances of sexual harassment coming to their attention will be subject to the same sanctions.

Employee Responsibility to the Working Environment

Given the nature of this type of discrimination, Sandia recognizes that false accusations can have serious effects on innocent employees. I trust that all employees will continue to act responsibly to establish a pleasant working environment free from all discrimination.

HANDICAPPED/VETERANS

Policy on the Handicapped and Veterans

Sandia's policy of equal employment opportunity for all its employees and applicants includes the commitment to full compliance with

- the Rehabilitation Act of 1973, as amended
- the revised Vietnam Era Veteran's Readjustment Assistance Act of 1974.

We will foster a general understanding of and sensitivity to the problems of the handicapped and veterans to assure that as openings become available for which they are qualified, we may be better prepared to provide meaningful employment and advancement opportunities.

Individuals Covered by the Acts

The Rehabilitation Act covers individuals with physical or mental impairments which could affect their ability to secure, retain, or advance in employment, whether or not they have previously been identified as handicapped. The Readjustment Assistance Act assures the Vietnam era veterans that employers will offer them employment opportunities with the likelihood for advancement.

How to Receive Consideration

Employees and applicants who believe themselves covered by the regulations and who wish to receive consideration under our affirmative action program are invited, at their own discretion, to identify themselves as handicapped or a covered veteran through their

- supervisors
- Personnel Representatives, or
- the EEO/AA Staff.

Information is Confidential

The information submitted will be considered confidential and will be used only as required to meet the provisions of the Acts.

Refusal to provide the information will not subject any employee or applicant to adverse treatment. Employees and applicants are also protected from coercion, intimidation, interference or discrimination for filing a complaint or assisting in an investigation under the Act.

Assure Success

To assure the success of our policy and our continued compliance with applicable laws and regulations, supervisors are reminded that it is the responsibility of each of us to provide equal employment opportunities for the qualified mentally or physically handicapped individual, and for the disabled, special disabled, and Vietnam era veteran.

Overall administration and monitoring of the program has been delegated to R. C. Bonner, Director of Personnel, and his staff.

EEO

Call for Cooperation and Support

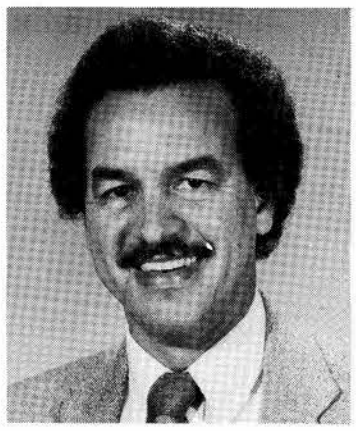
Full implementation of and compliance with the above policies will go far to ensure a positive and productive working environment for us all. I trust that we will receive full cooperation and support from all Sandians.

Irwin Welber

February, 1987

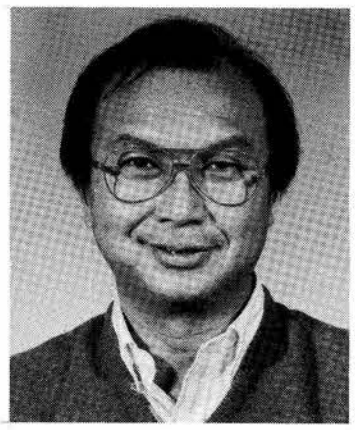
MILEPOSTS
LAB NEWS

MARCH 1987

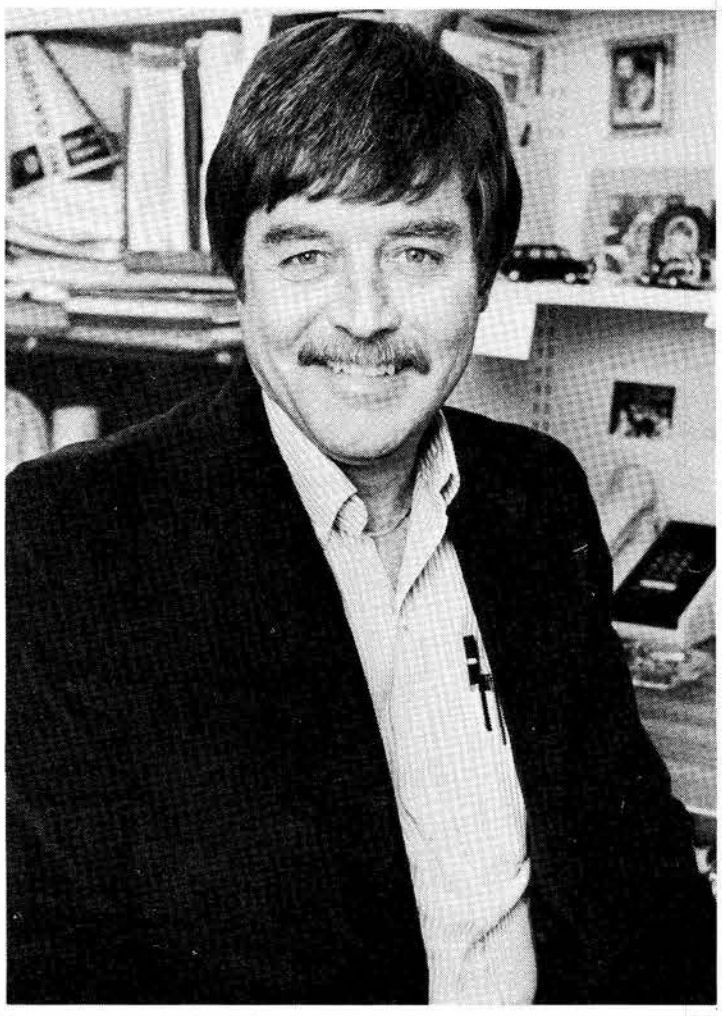


Nestor Ortiz (6410) 10

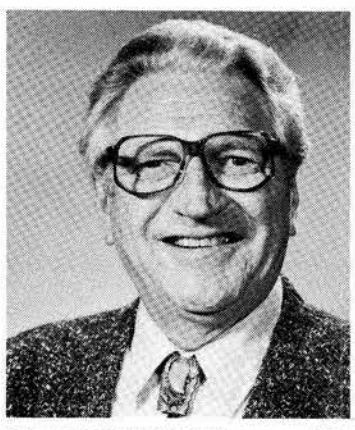
Mary Fischer (7818) 35



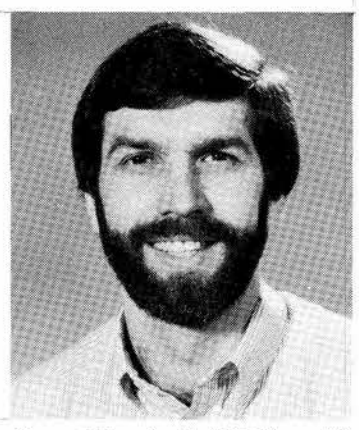
David Lee (9243) 20



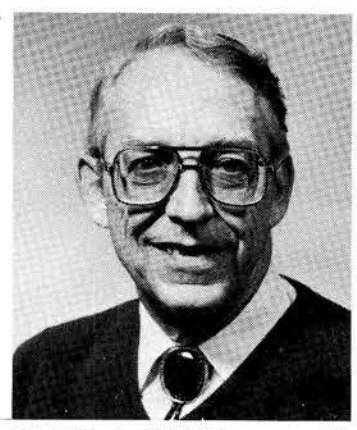
Dennis Mangan (5217) 25



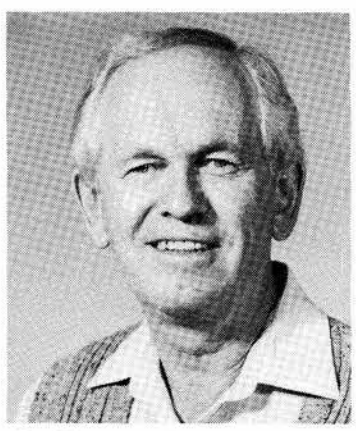
Glen McFall (7241) 35



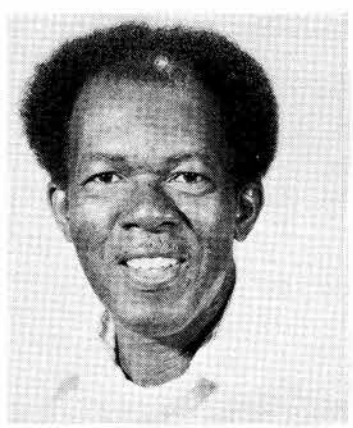
Norm Warpinski (6253) 10



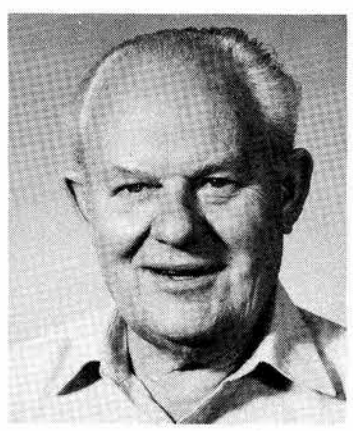
Dick Doyle (3315) 30



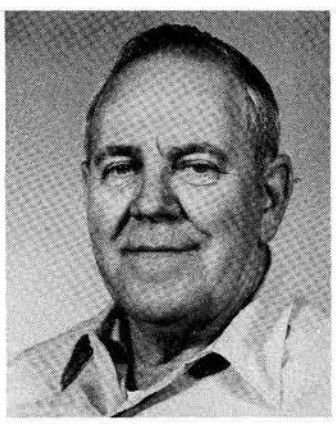
Jim Simpson (5238) 35



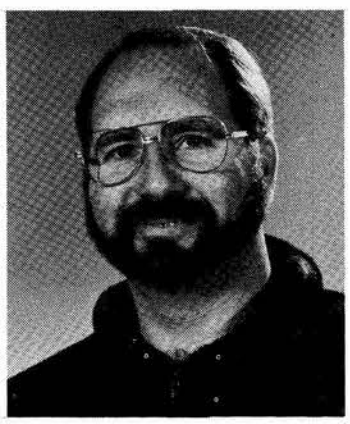
Eddy McClain (3426) 10



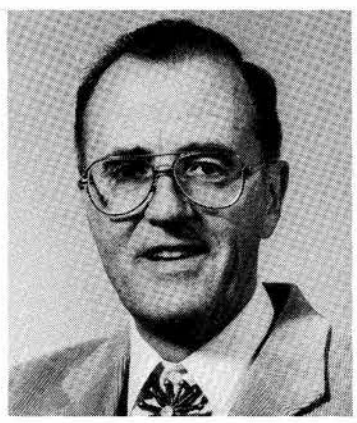
Alton Anderson (2565) 35



Charlie Thomson (7812) 30

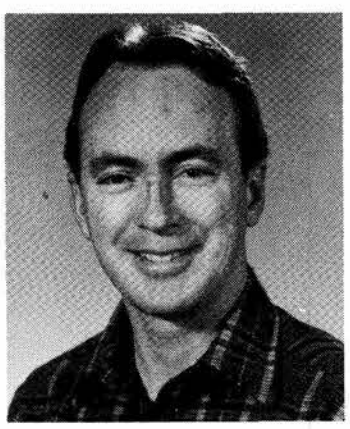


Zane Lawson (1845) 10

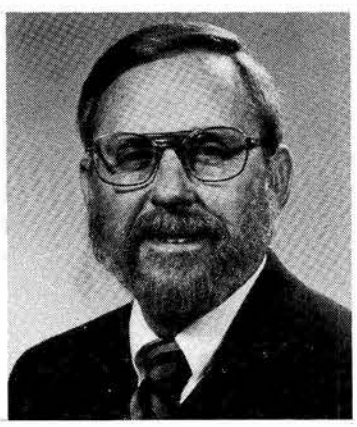


Hugh Church (6321) 30

Bob Sharp (7864) 30



Sam Holmes (7555) 10



Frank Ross (7262) 30

Cecil Sonnier (DMTS, 5217) 30

Congratulations

To Lorraine and Anthony (5144) Montoya, a son, Matthew Lawrence, Feb. 13.

To Leslie (2857) and Gary (9221) Ashcraft, a son, Berky William, Feb. 28.

To Theresa and Dennis (1523) Flanagan, a daughter, Eileen Mary, March 8.

To Jennie Negin (3411) and Harold Folley (4010), married in Albuquerque, March 11.

Welcome

Albuquerque

Gary Cordes (1831)
Roxanna Garcia (3428)
Michael Thomas (1134)

Colorado

Charles Barbour (1111)

New Mexico

John McGurn (1273)
Larry Shultz (1128)

Ohio

Wayne Buttry (1823)

Sympathy

To Larry Greher (4010) on the death of his father in North Miami Beach, Fla., Feb. 28, and his father-in-law in Brooklyn, N.Y., March 7.

To Michael Allen (6422) on the death of his father in Mississippi, March 14.

To Dominic Russell (3414) on the death of his wife in Albuquerque, March 15.

UNCLASSIFIED ADVERTISEMENTS • UNCLASSIFIED ADVERTISEMENTS • UNCLASSIFIED ADVERTISEMENTS • UNCLASSIFIED ADVERTISEMENTS

Deadline: Friday noon before week of publication unless changed by holiday. Mail to Div. 3162.

Ad Rules

1. Limit 20 words, including last name and home phone.
2. Include organization and full name with each ad submission.
3. Submit each ad in writing. No phone-ins.
4. Use 8½ by 11-inch paper.
5. Use separate sheet for each ad category.
6. Type or print ads legibly; use only accepted abbreviations.
7. One ad per category per issue.
8. No more than two insertions of same ad.
9. No "For Rent" ads except for employees on temporary assignment.
10. No commercial ads.
11. For active and retired Sandians and DOE employees.
12. Housing listed for sale is available for occupancy without regard to race, creed, color, or national origin.

MISCELLANEOUS

FUEL-SAVER THERMOSTAT, Honeywell microelectronic, for heating/cooling subbase Q6000A-1005, new in box, $50. Giachino, 821-6351.

HIGH CHAIR, $30; car seat, $25. Montano, 294-4238.

TI PORTABLE COMPUTER, professional, 256K, dual floppy, software, TI855 near-letter-quality printer, all for $950 OBO. Grafe, 291-9692.

HIGH-CAPACITY WATER SOFTENER, Sears, never used, includes bypass valves and filter housing, $275. Hardin, 828-1502.

CLEANER, household scrub-brusher, Black and Decker, cordless, hangs and recharges in wall bracket, $15. Barr, 821-5870.

COUCH and matching chair, $60 OBO. Heifetz, 275-2648.

PUSH MOWER w/catcher, $20; portable dishwasher, $40; armchair, needs upholstery, Queen Anne legs, $15; coffee table, $5. Robinson, 822-0180.

STEEL-SASH WINDOWS, 2 guitar pedals, Harley-Davidson Sportster king/queen seat, firescreen and tools, skittle pool. Gonzales, 344-4933.

WATER PURIFIER, portable, snap-on, Culligan, $25; French provincial twin bed w/canopy, complete, $75. Hovorka, 299-0224.

20-GAL. AQUARIUM w/stand, complete, $40; two 10-gal. aquariums w/stand, complete, $60. Mozley, 884-3453 leave message.

CORNER SOFA, 2 pieces, 6 cushions, 1 yr. old, cost $1000, asking $600 OBO. Middleton, 299-6148.

GOLF CLUBS: 1 set of 8 irons, 3 woods, $75; 1 set of 8 irons, 3 woods, $50; 3 woods, Titleist, $50; 2 B&W TVs, $25/ea. Krahling, 268-8126.

BLACK MARE, for beginning rider or child, 14.3 hands, 15 yrs. old, $500. Hansche, 281-5623.

KING-SIZE WATER BED, w/under-bed storage, $250. Sample, 865-4771.

HEIERLING X-C SKI BOOTS, size 35, $15. Wagner, 293-3211.

BALDWIN STUDIO-SIZE PIANO w/bench, walnut finish, 2 yrs. old, cost $3300, asking $2200. Sherman, 292-3297 evenings.

FREEZER, $200; desk and chair, $30. Lackey, 869-9333.

GE HEAVY-DUTY DRYER, $75; king-size waterbed, $50; child's contemporary bedroom set: twin bed w/drawers underneath, bookcase headboard, dresser, and desk, $150; small wooden desk, $20; antique oak chest, $80. Jones, 298-2067.

M-GAUGE TRAIN: 17 engines, 112 rolling stock, 125-ft. track mounted on homosote board, 30 pieces new flex track, 25 pieces new cork. Stuart, 299-9190.

CAMPER, 1977 Venture (Starcraft) Canterbury, sleeps 6, 3-burner stove, icebox, $1300 OBO. Kinsey, 294-2690.

SILKY TERRIER, AKC, female, 17 mos. old, to good home, $50. Coe, 266-6579.

UPHOLSTERED CHAIR, blue; 40" round maple coffee table, 42" round maple table w/6 chairs and leaves; extra-long twin bed. Puhara, 255-7447.

SAILBOARDS: Tencate "Funfan," 140 liter, 10'10" w/complete rig, $575 OBO; Rocket 83, 102 liters, $195; RAF 5.8 sail, $180. Healer, 298-6967.

GARAGE SALE: chair, table, lamp, misc., March 28 & 29, 10 a.m.-2 p.m., 6927 Arvilla Pl. NE. Duvall, 881-4406.

CUSTOM-MADE DRAPES, 212" x 94", includes rods and sheers, $125. Robinson, 883-4964.

BUNK BED FRAME, solid 2x6 construction, $110. Creighton, 292-6805.

MOTORCYCLE HELMETS: Shoei, large-size, full-face, $50; Nolan, medium-size, full-face, $35. Smith, 892-2516.

DESIGNER DRESSES for teenager, size 14-16. Wagner, 293-3211.

JAYCO POP-UP TRAILER, Jayeagle, sleeps 8, empty weight 1500 lbs., $1800 OBO. Benham, 881-2593.

ENGAGEMENT RING, .5 carat, solitaire, set in 14K gold. Solis, 243-5026.

TWIN BED: mattress, box spring, frame, $30. Rowe, 881-6159.

SOFA, traditional-style, 3-cushion, 89" long, gold velvet, $175. Rainhart, 821-3690.

CHINESE HAND-MADE WOOL RUG, 6' x 9', appraised at $1500, asking $1000. Mills, 764-9734.

.22-CAL. RIFLE w/scope, $50; Coleman tent heater, $20; Wagner power roller, $45; full-size bed, $50. Mowry, 299-2526.

ALUMINUM STORM DOOR, 36", LH; kitchen sink, white cast iron, best offer. Gendreau, 268-3436.

CAMPER SHELL, LWB, insulated, crank side windows, slide front and rear windows, screens, $200. Breeze, 294-3756.

ELECTRIC ICE CREAM MAKER, 4-qt. capacity, $15. Clark, 292-1495.

HOME COMPUTER, TI99/4A, color monitor, printer, two disk drives, modem, Pascal, word processing, spreadsheet, speech, games, $1000 OBO. Shipley, 888-1666.

CLARINET, Bluescher, w/reeds, case, and book, $150. Barnaby, 265-4353.

GUITAR AMP, Marshall JCM 800, 50-watt lead, $450. Jaramillo, 831-6415.

NETHERLAND DWARF miniature rabbits, many colors. Sharp, 243-1498.

SCOTTY CAMPING TRAILER, 15', sleeps 4-5, furnace, stove, icebox, Port-a-Potty, $1500. Pfeiffer, 299-3951.

SLIDE PROJECTOR, Sawyer, manual operation, $30; GAF rotary slide trays, $2 and $3. Hendrick, 296-2163.

FREE DOG HOUSE, 28"W, 32"D, 14"H, 27" floor to top of lift-off roof; CJ5 manual. Pierce, 299-2801.

ZERO HALIBURTON CASE, 24" x 18" x 6", lock, foam, $400 new, sell for $250 OBO. Eley, 242-8530.

CARDBOARD MOVING BOXES, medium (3.1 cu. ft.), and book (2+ cu. ft.), 50¢ ea. Roeske, 255-6188.

FLOOR-LENGTH FORMALS: white, size 9, $20; lavender lace, worn once, size 11, $35. Waite, 867-5953.

FIESTAWARE: 12 plates, 1 platter, $100; new Super 8 movie camera, $20. Gaither, 298-1043.

TILLER, Sears Craftsman, 5-hp, rear-tine, self-propelled, 2 yrs. old, $550. Linnerooth, 299-6558.

ICOM IC-2AT VHF RADIO, hand-held, 144-148 MHz, touch-tone pad, charger, $175. Hufnagel, 294-5949.

OIL COOLER, fits Chev. engine, complete, used one season, $20. Marchi, 291-9681.

OBOE, Selmer Signet, intermediate, silver keys, $300. Weaver, 255-2385 after 5.

LOVESEAT, red, upholstered, $50. Grey, 299-7349.

RECLINER, 3-position, brown, $45; pair of vanity lamps, $15; braided rugs: hall, 2' x 9', $15; oval, 3' x 6', $5; Samsonite 26" w/hangers, $5. Easton, 256-7717.

H-89 COMPUTER SYSTEM w/Magnolia Microsystems add-ons, software includes professional Wordstar and Pearl, $950 OBO. Schuh, 822-9824.

FLUORESCENT LIGHT FIXTURES, 8-ft. double, remodeling surplus, less than half the new price, $10/ea. Atkins, 298-5762.

SHETLAND SHEEPDOG PUPPY (miniature collie), female, AKC, shots, champion sire, 10 weeks old, $150. Essenmacher, 865-7066.

ANTIQUE BIRD'S-EYE MAPLE DRESSER w/beveled mirror; 10" Craftsman table saw, extras. Westman, 881-0471.

JAYCO EAGLE pop-up camping trailer, sleeps 8, stove, icebox, heater, water system, $1950. Caskey, 296-6372.

ELECTRIC GUITAR, Ibanez Proline, locking tremolo, fine tuners, hard case, less than a year old, $475. Ewing, 268-6920.

MISCELLANEOUS ELECTRICAL items for home use. Burstein, 821-6688 after 5:30.

WATER BED, super single-size (4' x7'), w/bookcase headboard, pedestal, heater, liner, and non-leaking mattress, $75 OBO. Kirby, 299-2948.

TIRES AND WHEELS: set of 5, LT235/75R15, Goodrich radial all-terrain on 15" Toyota SR-5 white spoke wheels. Fisher, 298-0526.

MORGAN FLOTATION SYSTEM: soft-sided queen-size waterbed, dual heaters, $300 OBO. Breckenridge, 291-0039.

GERMAN SHORTHAIR POINTERS, male and female, purebred, AKC-registered, all shots, 8 months old. Proctor, 821-8927 after 5.

ECHO CHAIN SAW, Electrovoice speakers, corduroy ski suit, queen-size pine poster bed, full wet suit, sail cloth, best offers. Blake, 881-1663.

COLOR TVs: 25" console and 19", $125 and $75; Roper dishwasher, $25. Sorensen, 822-1733.

TRANSPORTATION

'83 HONDA XL500R, 4K miles, one owner, includes helmet, cover, manual, $900. Smith, 298-2165.

'84 DODGE DAYTONA TURBO, louvres, AC, AT, stereo, cruise, 4-cyl., electronic fuel injection. Liguori, 256-3613.

3-SPD. BICYCLE, AMF Conqueror, $25. Smiel, 865-9081.

14' FLAT-BOTTOM BOAT, aluminum, Aerocraft. Bronkema, 821-2119.

'79 SUBARU BRAT 4x4, w/camper shell, $1200 OBO or trade. Gibson, 344-8056.

'70 MERCEDES BENZ. Perea, 242-9175.

MEN'S 10-SPD. BICYCLE, Univega, 31 to 31-1/2, quick-release front wheel, $150. Paul, 299-6387.

'79 DODGE D-150 PICKUP, stepside, AC, AT, 318 V-8, $2200. Payne, 299-5966.

'83 SUBARU SW, loaded, AC, PB, PS, stereo, electric windows, under book, $5200. Lackey, 869-9333.

BOY'S 26" BICYCLE, $60. Robinson, 883-4964.

'69 PLYMOUTH SATELLITE, 318 V-8, one owner, $800 OBO. Jones, 298-2067.

RD YAMAHAS: 400 "Daytona", $975; '75 350, $575. Lachenmeyer, 268-7475.

'84 HONDA PRELUDE, AC, AM/FM cassette, sunroof, original owner, $9200 OBO. Woodall, 822-0060.

'82 YAMAHA VISION MOTORCYCLE, 550cc, w/'83-style fairing, 6.3K miles, luggage rack w/backrest, $1200. Micono, 275-0478.

MEN'S BICYCLES: 10-spd., $50; 3-spd., $35; both for $75. Joseph, 299-6989.

BICYCLE, "Team Fugi," 23" frame, 700x 25c wheels, Turbo "S" tires, $200 OBO. Benecke, 255-1356.

'82 PLYMOUTH HORIZON, 4-dr., 4-spd., one owner, $2000. Behe, 281-2735 after 7.

'84 HONDA, V-6S Sabre, tinted windshield, V-rated tires, 1100cc, 6-spd., drive shaft, water-cooled, quartz headlamp. Rasmussen, 266-1097.

'81 SUZUKI GS450, sport and commuter bike, 8K miles, garaged, new tire and battery, $850. Hickerson, 281-2598.

'80 MAZDA RX-7, 2K stereo system, alarm, extras, $5900. Ulibarri, 892-5759.

'84 VW RABBIT GTI, AC, AM/FM cassette, $5495 OBO. Lyons, 842-0304 or 836-4900.

CENTURION LEMANS BICYCLE, 12-spd., 21" men's frame, 27" wheels. McCornack, 296-3936.

'75 PINTO SW, 4-spd., 2-yr. clutch, $500 OBO. Johnson, 296-1917.

'77 YAMAHA 500XSD w/fairing, new tires, $700. Mowry, 299-2526.

'54 FORD CUSTOMLINER, 6-cyl., 3-spd., $1800; MGA parts, misc. Schaub, 821-7242 after 5.

'82 PLYMOUTH RELIANT, 4-dr., AC, AM/FM stereo, $2500. Nelson, 268-0208.

'84 VW RABBIT, 5-spd., fuel-injected, cloth interior, 2-dr., Alpine AM/FM cassette, AC, $3950 OBO. Smith, 892-2516.

NISHIKI INTERNATIONAL BICYCLE, 25", CrMo double-butted frame, alloy wheels, completely reconditioned - tires, chain, etc., adult-ridden, $175. Dippold, 821-5750.

WOMEN'S 10-SPD. BICYCLE, Takara, 26", $45. Gendreau, 268-3436.

'86 SUZUKI SAMURAI JX 4x4 convertible, 5-spd., AM/FM cassette, 3K miles, extras, $7400. Clark, 292-1495.

KID'S BICYCLE, 16", sidewalk bike; tricycle. Passman, 821-4999.

'84 NISSAN SENTRA DL, 4-dr. sedan, 5-spd., AC, AM/FM, 23.5K miles, $5000 OBO. Garrison, 281-1539.

ATB BICYCLE, 21", Univega Bio Pace, chain ring, $250. Gronseth, 299-3540.

'78 DODGE ASPEN, recent engine overhaul, one owner, $850. Weaver, 255-2385 after 5.

'76 DATSUN LB PICKUP, AC, camper shell, CB, new clutch and upholstery, radial tires, $1600. Atkins, 298-5762.

'86 VF500 INTERCEPTOR, 5.4K miles, 3-yr. warranty, $2500 firm. Tessler, 296-7587.

'81 HONDA CB750, 14K miles, extras, $1100. Chown, 891-8637.

WOMEN'S 26" BIKE, has both hand and coaster brakes, $75. Burstein, 821-6688 after 5:30.

'80 SUBARU WAGON, 4-wheel drive, $1400. Hansche, 281-5623.

'83 BUICK LeSABRE, V-6, loaded, 2-tone paint, new tires and brakes, cassette stereo, $4950. Stewart, 293-3959.

RACING BIKE: Peugeot PSN10, 63cm frame, Campy Victory group and modolo brakes, one yr. old, $400. Mogford, 897-1038.

REAL ESTATE

3-BDR. MOBILE HOME, '85 Nashua double-wide, 28' x 56', 1400 sq. ft., 2 baths, utility room, FP, under appraisal, low equity, low down, Van Cleave Mobile Home Park (Central & Moon). Randolph, 299-2057 or 292-4243.

PICKARD TRIPLEX, built 1978, Menaul east of Chelwood, rents for $1175, 3100 sq. ft., $147,000 terms negotiable. Lachenmeyer, 268-7475.

2-BDR. HOME, Rio Rancho, 1 bath, landscaped, near golf course, less than 1-1/2 yrs. old, $6600 down, take over assumable loan. Apodaca, 892-2435.

15 ACRES in the Manzano Mtns., 30 miles south of Albuquerque on Hwy. 14, $25,000. Sena, 299-4085.

2-BDR. HOME, NE, 1-3/4 baths, open floor plan, earthtone interior, mini-blinds throughout, 2 yrs. old, $69,500. Padilla, 821-5906.

TIMESHARE AND LOT in Hot Springs, Ark., cash/terms. Griffin, 298-1174.

3-BDR. HOME, Taylor Ranch, 1900 sq. ft., 2 baths, formal DR, 2-car garage, extras, assumable FHA. Lyons, 842-0304 or 836-4900.

2-BDR. TOWNHOUSE near Ladera golf course, fenced-in back yard, low 60s. Padilla, 831-0330.

WANTED

GRAFLEX GRAPHIC VIEW II CAMERA and/or Grafloc back for same. Mattox, 292-7763.

PING PONG TABLE, folding. Villanueva, 296-0970.

TRUCK BED to fit '83 Toyota LB frame. Eley, 242-8530.

LAWN MOWER, electric or push, in good condition; fertilizer spreader. Patterson, 822-1196.

WHITE DRESS for First Communion, buy or rent, for 7-yr.-old girl. Wagner, 293-3211.

CHEAP PUSH MOWER. Mason, 281-3052.

BRIDGE BULLETINS to borrow: copies of the January and February "Contract Bridge Bulletins." Miller, 255-7716.

FLY RODS AND REELS, will trade for rifles, shotguns, and handguns, also have compound bow. Tessler, 296-7587.

RELIABLE SITTER, preferably located near KAFB, for newborn, 1-2 days per week, references required. Cox, 892-2906.

CABOVER CAMPER, 9' to 11', w/bath, to fit Ford 1-ton pickup, price negotiable on condition. Shipp, 822-9824.

CUSTOMERS FOR FLEA MARKET, arts & crafts, bake sale, all day April 4 (rain check April 11), corner Candelaria/Pennsylvania, sponsored by Sandia High Band Boosters. Caskey, 296-6372.

LOST AND FOUND

RED AND WHITE BASEBALL CAP w/UNM and other pins, possibly lost in Technology Transfer Center on March 18 at supercomputer symposium. Key, 298-7988.

SHARE-A-RIDE

RIDE NEEDED from 13th & Coal to Area I. Aydelotte, 4-RIDE.

Get Along, Little Dogies — To Western Night on April 3

POOR LONESOME COWBOY? You really don't have to drift along with the tumbling tumbleweeds, you know . . . you could be at Western Night next Friday night (April 3) struttin' your stuff to the sagebrush-shuffle strains of those ever-popular Isleta Poor Boys. Beforehand, there's a mighty fine buffet ($6.95) featuring BBQ ribs and chicken, along with a full salad bar. From 7:30 to 8:30 p.m., take advantage of the free country/western dance lessons; then you'll be ready to wow 'em when the "real" dancing starts. Chuck wagon reservations requested (265-6791).

BRINKER WAS NO CLINKER — And you can find out why at Family Night on Saturday, April 4. Hans Brinker — certainly no Holland has-been — and his silver skates race across the big screen, starting at 6 p.m. A VLC (very-low-cost) buffet featuring all sorts of kid-pleasin' food (hamburgers, hot dogs, and pizza) starts out the festivities at 5. As always, the movie is free, and cokes and popcorn are available at just a quarter a throw.

TONIGHT, IT'S BROWN SUGAR to put you in a mambo mood as it belts out those Latin tunes from 8 p.m. to midnight. Feast on the two-for-one special, prime rib or halibut (your choice of two entrees, $14.95), before you hit the dance floor. Ask what else is cooking when you make your reservation; Chef Henry always comes up with a menu surprise or two for the dinner specials.

The Beat Goes On . . .

The VCP beat, that is. More seminars presented by local brokerage houses are on tap to help Sandians figure out what to do with those hard-earned VCP distributions. Topics include tax effects of distributions, available investment options, IRA rollovers, etc. On the schedule for early April:

April 1 - E. F. Hutton (Greg Zanetti), 4:45-6 p.m., Eldorado room.

April 2 - A. G. Edwards & Sons (Findlay Edwards and Christie Harper), 4:30-5:15 p.m., Eldorado room.

April 8 - Dean Witter Reynolds (Michael DeVincentis, Bill Donald, Bill Wiley, and Steven Stubbs), 5-6:30 p.m., Eldorado room.

SHARKS SHARE SECRETS on table skills at every one of those T-Bird cardplaying sessions. Mostly, they're scheming to come up with ways to beat the dealers in tinsel town, we're told! (But they're also having some good old-fashioned fun, along with some of the best munchies in town.) Next month's get-togethers are on April 2, April 16, and April 30, starting at 10:30 a.m. all three days. Our spies tell us that turnouts are bigger and better each time the sharks circle. No wonder . . . that's where the action is!

Another big day for Thunderbird retirees — especially those with itchy feet — is Monday, April 13. Sun Tours presents a special travel program/slide show that day for T-Birds at the south end of the ballroom, starting at 1 p.m. Plan to meet your friends ahead of time for lunch (noonish, suggests honcho Charlie Kaspar). After Sun Tours does its thing, you can find out what the T-Bird Board has up its collective sleeve at the group's monthly meeting.

AN EGGSTRAORDINARY EASTER is what's on tap for all the folks who show up on Easter Sunday at the Club for its fabulous holiday brunch, served from 10 a.m. to 2 p.m. The buffet menu is something else! The goodies: Virginia baked ham with cherry sauce, baron of beef, fried chicken, green beans almondine, potatoes au gratin, Denver omelets, scrambled eggs, sausage, green chile salsa, hash browns, mini-bagels with cream cheese, French rolls, blueberry crumb cake, chilled juices, fresh fruit salad and tossed salad, assorted cheese tray, vegetable trays with dip, a medley of desserts, and beverages (coffee, tea, and milk). And speaking of beverages, there's a complimentary glass of champagne for brunch-goers, too (if they're old enough, that is!). It's a treat for the whole family at very reasonable prices: adults, $10.50; children ages 5-12, $5.75; and tots 4 and under, free. Celebrate a special day in a special way; but hurry on that reservation. Space is limited, and this is always a very popular event.

SPEAKING OF POPULAR EVENTS, kids are hopping down the bunny trail on Saturday, April 11, when the annual Easter egg hunt and egg roll (not the Chinese kind) get under way. Children — divided into age groups — hunt and roll that day from 10 a.m. to noon, and pick up some neat prizes along the way. The guest star of the day is hare today, gone tomorrow, and always draws big crowds — so the party's limited to members' children only. Don't forget your membership cards!

ALSO NO SLOUCHES in the popularity contest are Don Lesmen and his crew, who bring back those Big Band sounds to the Club on Friday night, April 10. Closet children of the 40s and 50s — here's your big chance to swing and sway to meaningful music (you can understand the words). The two-for-one special that night features filet mignon or halibut — not a bad way to start out the evening. Then trip the light fantastic from 8:30 to 11:30 p.m.

A FRUSTRATED ESTHER WILLIAMS? You don't have to be if you join the swimming mamas co-op (sounds like a new rock group, right?), now being formed to share kid-watching duties at the pool/patio this summer. It's all very simple: You watch another mother's children while she's off doing laps, and then she does the same for you. All very informal, we're told. For more information, contact Mary Lauffer at 265-7218.

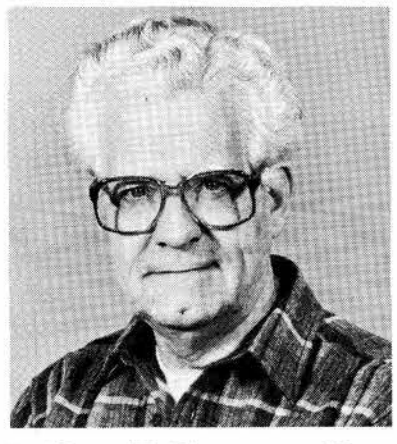
IS YOU IS OR IS YOU AIN'T going to sign up for some of those super sojourns planned and orchestrated by the C-Club Travel Committee? If you ain't, you're missing out on some fantastic vacation opportunities. Here's a sampling:

Sedona Serenity — Relax and enjoy this bus trip to Sedona, Ariz., by way of Flagstaff, May 9-12. Sightseeing includes the Painted Desert and Petrified Forest, Montezuma Castle National Monument, Fort Verde State Park, Jerome State Historical Park (a famous ghost town), and Meteor Crater. A visit to Prescott, the territorial capital, is on the agenda too. Oak Creek Canyon — between Flagstaff and Sedona — is always beautiful, but it's simply spectacular in the spring. The low tab of $170/person includes three nights' lodging, RT bus fare, and snacks and drinks along the way.

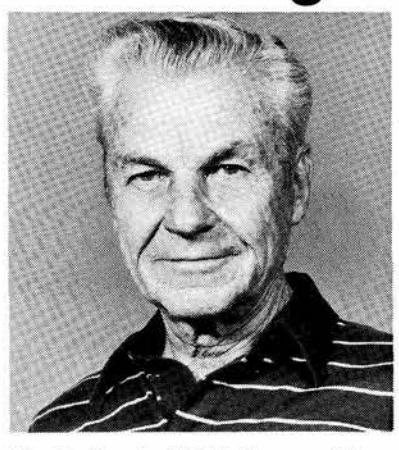
Denver, Definitely — Is what you'll say to all your friends after you've visited that town in our neighboring state to the north. Itinerary for this five-day tour (June 3-7) includes lunch on the bank of the Rio Grande in Alamosa; visits to Leadville, the restored mining town of Central City, and Buffalo Bill's gravesite; and a tour of the Coors ("is the one") Brewery in Golden. In Colorado Springs, see the Air Force Academy, Garden of the Gods, Cheyenne Mountain Observatory, and the venerable Broadmoor Hotel; that night, it's dinner and a show at the Flying W BBQ in Colo. Springs. You'll tour the Mint and some very fine museums during your day in Denver. Rounding out this memorable trip are visits to Royal Gorge and Salida. The price of $248/ person (double) covers RT bus fare, four nights' lodging, and all admission fees.

Alaska Annals — Are what you'll write after you return from this blockbuster of a trip to our largest state. This cruise/land (or cruise only) adventure has to be one of this year's biggies. The cruise/land option (Sept. 8-20) includes city tours of Anchorage and Fairbanks, a stern-wheeler cruise, and a visit to Mt. McKinley National Park before travelers get aboard the luxurious *Regent Sea* for a week-long cruise (Sept. 13-20) along the coast of Alaska. Ports of call include Ketchikan, Juneau, Skagway, and Vancouver. Cost of the complete cruise/land package is $2325/person (double); for cruise-only types, it's $1642. Included are all transportation costs (land/sea/air), lodging along the way, all meals while you're aboard the *Regent Sea*, and taxes/tips. Don't forget — you get price breaks on triple and quad occupancy. Final payment isn't due until July 20.

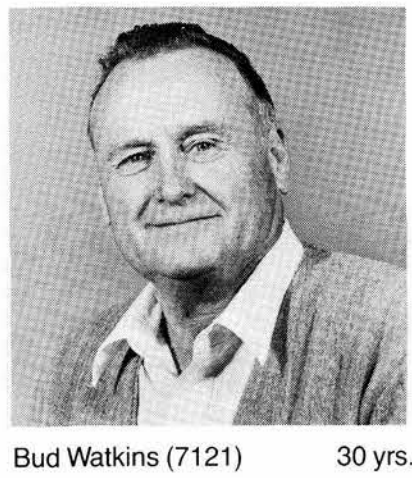
Retiring



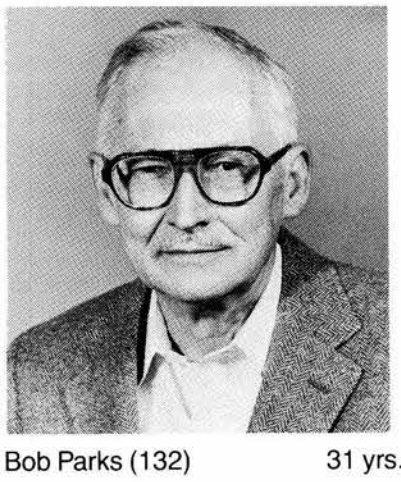
Earl Scott (7242) 29 yrs.



Morris Goebel (5114) 35 yrs.

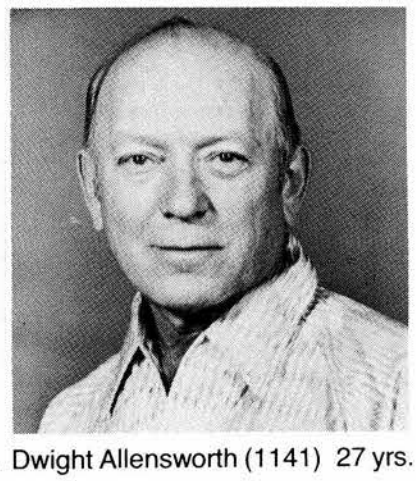


Bud Watkins (7121) 30 yrs.



Bob Parks (132) 31 yrs.

Jim Stoever (7116) 33 yrs.



Dwight Allensworth (1141) 27 yrs.

(Continued from CRM Four)

CRM

sizes. "We want the main thrust of the external work to yield products that, in a number of years, could become CRM catalog parts that would be available for design into weapon systems, once reliability and producibility have been assured."

There is additional rationale for the reimbursable work. "The CRM has unique microelectronics capabilities needed by many national programs," Bob says. "We should respond to those needs, if time permits."

An often-asked question about the CRM concerns the division of labor between Sandia and BAO. That arrangement, in fact, just completed a three-year evolution into its current state.

When the CRM was established, Sandia held responsiblity for both development and production of DOE-required radiation-hardened silicon ICs. Former Sandia President George Dacey soon questioned the wisdom of that setup. "It was his opinion," Doug Weaver recalls, "that R&D, which was then and remains today the Center's major mission, would suffer because of stresses imposed by fabrication."

So, in 1982 Sandia, DOE, and Allied Corporation's Bendix Kansas City Division agreed to establish BAO and to begin phasing in its responsibilities for fabrication, packaging, and certification testing.

What Now, CRM?

Where, then, is the CRM headed? And what hurdles must it clear to reach its goals?

The hurdle that presents itself first in the minds of Small Staff is affordability.

"This is an industry-wide problem, not just a concern for the CRM," Larry says. "The lifetime of each IC generation can be as short as two or three years, and because it is so expensive to progress from generation to generation, we see a very steep cost-increase curve. We must resolve the question of whether we can continue to pay these escalating costs.

"There are several approaches to tempering increasing costs," Larry continues. "One is sharing costs with other entities that also are interested in new technologies. We've done that with Bell Labs as a way of developing ICs with one-micron features, which both the CRM and Bell Labs expect to be building in a matter of years.

"We also must examine the possibility of having the CRM accept a somewhat narrower role in the semiconductor business."

Dale Clements echoes the cost crisis: "We need to utilize resources as efficiently as possible. We need to carefully search for, and minimize, redundancies in the Sandia and BAO branches of the Center."

Two other concerns stand out on Dale's list: "Manufacturing performance must be consistently high. The Center also must never forget that it is a service organization. We must always be responsive to customers. We need quick delivery of prototype devices, followed by thorough attention to production schedules."

The exact path that the CRM will follow — and thus the identity that it will assume during the next 10 years — is extremely hard to predict. In an article about solid state technology in the year 2001, which is scheduled for publication in *Radioelectronics Magazine*, Bob Gregory writes: "It's always been relatively straightforward to predict the 'next generation' technology. The problem of getting there is largely one of execution. It's not too difficult to predict the generation after that . . ."

Great-great-great-grandchildren's Looks

"Beyond the next two generations, predictions become inexact. We frequently extrapolate past rates of progress into the future, defining where we will be without providing the details of how to get there. Extrapolating five generations into the future [that is, 2001], using the human analogy, is like trying to predict the appearance, traits, and life styles of your great-great-great-grandchildren."

However, Bob, whose past bets on R&D directions have often proven correct, has looked into his crystal ball for LAB NEWS: "As we approach sub-micron feature sizes [something that the manufacturers of non-hardened ICs have already achieved], it will become much harder to design against the effects of transient radiation. However, new designs that provide total-dose hardness possibly 10 times greater [than the 10-million-rad level the CRM recently reached] should actually become easier (see "Hardening Chips" story).

"Designs that address this apparent paradox will have to rely on a special branch of CMOS technology, called SOI [silicon on insulator]," Bob continues. "We're some distance from a viable radiation-hard SOI technology."

Ray Bair, manager of Integrated Circuit Design Department 2110, believes customer demands and desires will steer the CRM in specific ways.

"Instead of striving primarily for ever-smaller IC features," he says, "the CRM may actually be most helpful to its customers by identifying innovative uses of ICs — for example, by developing a group of building-block application-specific ICs (ASICs) that can be pulled off the shelf and quickly adapted to perform a range of tasks."

He also expects widespread use of new, more complex gate arrays that are now being developed in 2110. Currently, the Center's mature gate array uses features as small as three microns and contains 1500 gates. Prototype two-micron feature size arrays with 5000 gates are being made, and researchers are looking forward to arrays with 10,000 and even 25,000 gates within the next five years. When finished as a functional unit, a gate array can exhibit a range of operational capabilities.

Ray also envisions ICs that combine true non-volatile memory capability with a microprocessor, and even conventional ROMs and RAMs, all on one chip.

Another futuristic CRM device is what Ray calls "the IC version of a tape recorder" that has about 4000 times the data storage capacity of a typical contemporary personal computer. Ray is careful to point out, however, that "in this case, I'm projecting a need rather than a capability."

And, finally, widespread discussion about the desirability of establishing a national semiconductor center that would be charged with repositioning this country's IC business on a more competitive international footing offers another future path for the CRM.

Says Sandia President Irwin Welber, "The CRM, with its combination of Sandia's R&D expertise, production capabilities offered by BAO, service orientation, and the arrival of its new world-class RHIC-II facility, has an unusual capability for helping to rebuild the U.S. presence in the semiconductor field."

● Rod Geer (3161)

For Insiders and Outsiders

A Customer's Guide to the CRM

How to do business with the CRM depends on whether "in-house" or "external" customers are involved.

There is, however, a common philosophy applied to either type of customer. "As a service organization, the CRM must help customers plan for reality," says Bill Lovejoy, supervisor of CRM Program Development/Management Division 2151.

"We must give customers reasonable expectations," Bill continues. "If we don't deliver a product consistent with those expectations, we can expect customers to be disappointed. Regular, meaningful updates of how a project is progressing and when we expect to complete it are musts."

The best first step for a first-time "in-house" user is to contact Div. 2151 so that one of its program managers can take the caller — generally a weapon subsystem or system designer — as a client.

"When we work with internal customers, we show them parts that we currently have designed and can produce," Bill explains. "Unfortunately, we don't have the capability to build a large inventory such as you'll see at a semiconductor distributor. In some cases we do have overbuild and we can pull the needed parts off the shelf, but typically we have to build for the customer."

If a new internal customer isn't sure what is needed to perform a specific task, the CRM's program manager explains the options. If maximized performance is necessary, a full custom chip may be required. If quick delivery is the priority, discussion may focus on the use of gate arrays or standard cells.

A gate array is somewhat like a pre-fab building that can be used as a small office building or a school classroom, depending on the final assembly. "It's a chip that's about 80 percent complete, including the processing that builds in radiation-hardness," explains Paul Elder, the 2151 customer relations officer who coordinates CRM's gate array deliveries.

"The final processing steps, essentially the electrical wiring, determine the task that it will perform," he adds. "Gate arrays can also be wired together to yield increased capability."

The CRM also has a collection of standard cells that fall somewhere in between custom chips and gate arrays. More transistors are packed into a given area on standard cells than on gate arrays, but the need for additional design and processing slows delivery of a test chip comprised of several standard cells that have been connected.

After making the custom chip/standard cell/gate array decision, the customer receives the tools necessary to complete a logic design — the description of what the chip will do and how it will get that job done. "When the logic design is done, we assist the customer in translating it into an IC," Bill says.

If the customer chooses a fully customized chip, at least 18 months will probably pass before a test chip is ready for study. However, a gate array could be ready in two to four months.

Two of the biggest hurdles for CRM program managers are to correctly predict the amount of time it will take for a given request to be completed, and then to make good on the prediction.

Parts Have Pedigrees

"When you require high-reliability parts," Bill explains, "you also want the quality assurance and quality control intervention at the proper steps so that your part has a pedigree. Achieving that pedigree slows completion of the project." So does the redesign work that's frequently necessary.

For the experienced internal customer, much of the initial discussion with the CRM is not necessary. This customer often can simply prepare a material requirement schedule for Div. 2151. "After receiving that document, we can initiate the project, or even begin parts production," Bill adds.

When possible, the CRM locates and buys commercially available parts that will fill the bill for both internal and external customers. During FY86, the CRM spent $7 million on qualification testing and procurement of radiation-hardened parts from some 60 commercial suppliers.

The external customer's path to the CRM flows through the Reimbursable Programs Branch of DOE's Albuquerque Operations Office, and is predicated on the Center's being able to perform the work on a non-interference basis with its primary DOE mission.

The demand for CRM parts has been so high, explains Horton Struve, the Branch's acting chief, that DOE has negotiated Memoranda of Understanding (MOU) with a variety of governmental agencies — the DoD, for example — that streamline the procedures by which potential CRM customers establish a valid government contract.

Here It Is, If You Want It

Technology Transfer and the CRM

During every workday — and occasionally on weekends — semiconductor experts at the Center for Radiation-hardened Microelectronics (CRM) consult in person or on the telephone with their technical counterparts at many of the major firms that design and build chips commercially.

"This rapid-fire exchange of technical knowledge and how-to-do-it understanding is one reason that our radiation-hardened semiconductor work produces technology transfer fruit so quickly," says Bob Stromberg, a supervisor in the Technology Transfer & Management Department 4030.

"On occasion, that transfer appears to occur almost immediately," Bob adds, "whereas, typically, several years can pass before Sandia-developed technologies transferred to industry actually appear in the marketplace."

A look at the special telephone directory provided to CRM staff provides clear evidence that technology transfer — whether accomplished via formal agreement, informal exchanges, or other means — is a prime mission. Along with the expected government agency contacts, the directory lists some 60 companies involved in designing, making, or using radiation-hardened parts, and more than a dozen universities and research centers that study radiation-hardening.

Even before the CRM was officially set up, Sandia had established its semiconductor technology transfer credentials with activities that have resulted, to date, in advanced R&D being conducted or commercially available parts being made at about one dozen companies.

Some of the earliest of these activities were with RCA, which, along with Sandia, became interested during the early- and mid-70s in developing a capability to design and make radiation-hardened chips.

"Following meetings with RCA in the early 70s," recalls Bob Gregory, Director of Microelectronics 2100, "we recognized that features of its 10-micron metal-gate CMOS technology could be hardened with the use of techniques that we had been investigating. Shortly after sharing that work with RCA, we began to see its influence on RCA designs."

Then, during 1979, further technology exchanges with RCA led to hardening five members of its 1802 silicon-gate CMOS microprocessor family.

Parts that resulted from this relationship with RCA were eventually built by RCA, Sandia, and even Harris Semiconductor. Some are now in stockpiled nuclear weapons and in orbiting satellites.

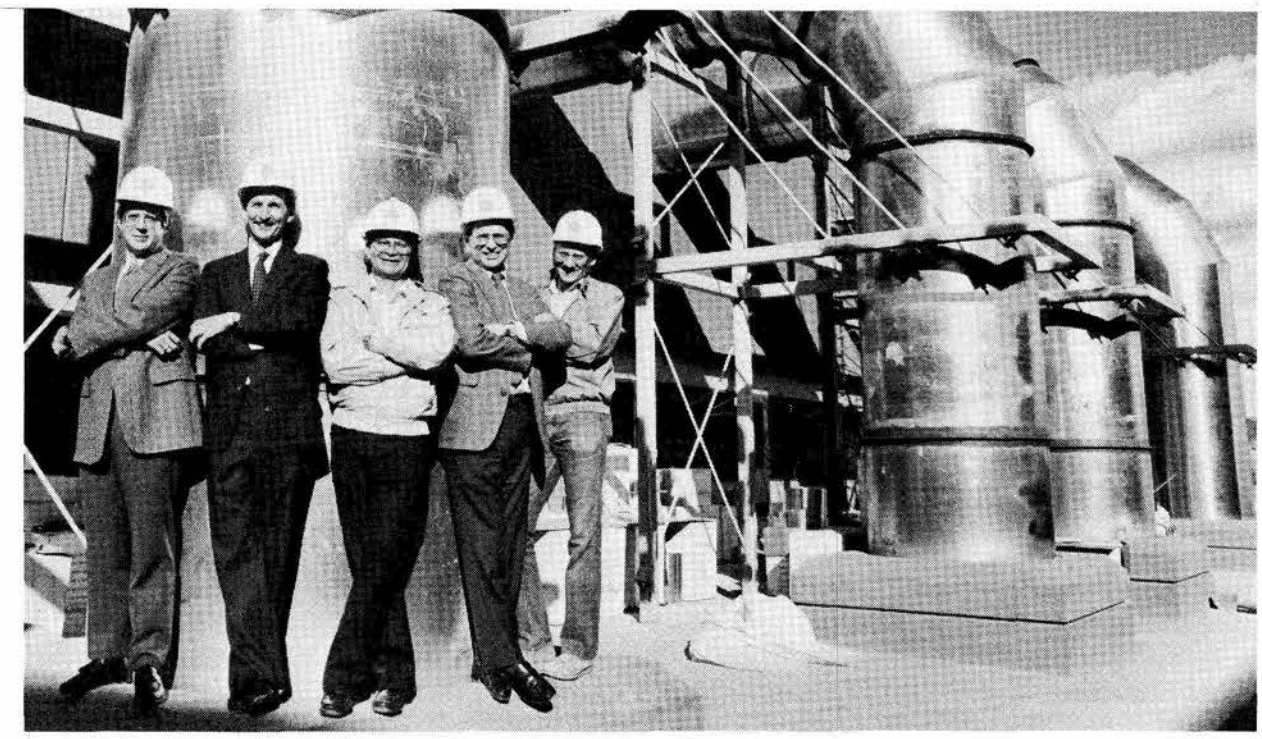
Concurrently with the earlier RCA exchange, National Semiconductor approached Sandia for help in learning chip-hardening.

"The work with National was a more traditional example of technology transfer than our exchanges with RCA," Bob Gregory explains. "We directly transferred our then-current technology to National so it could establish itself in the rad-hardening business. The resulting National process was identical to ours."

The CRM has worked closely with Intel, another giant in the world of microchips, since the early 80s when Intel provided the Center with the design package for its workhorse, but non-hardened, 8-bit microprocessor, the 8085. With that package, the CRM designed an electrically equivalent radiation-hardened version of the chip.

Then in 1983, when Intel decided not to produce the new part, the CRM arranged for Harris Semiconductor to make the device. General Electric also asked for and received the CRM's design and fabrication package for the part, so it could build it for GE defense programs.

The CRM and Intel struck their most recent agreement just last year. It calls for a radiation-hardened version of Intel's two-micron feature size 80C51 microcontroller. By the end of this year, the CRM expects to have produced an engineering prototype of the new chip, which incorporates a central processing unit, a RAM, and a ROM on a single piece of silicon.



SINCE 1973, these five Sandians have been continuously involved with organizations that are devoted to the research, development, and fabrication of radiation-hardened ICs. Relaxed against one of the distinctive RHIC-II supply air ducts are (from left) Doug Weaver (2130), Bob Gregory (2100), Luther Horning (2115), Ed Graham (2150), and Charlie Barnes (2133). In 1973, Bob was the division supervisor for the other four.

Since 1985, the CRM has worked closely with Martin Marietta, which wants to establish itself in the manufacture of the Center's two-micron CMOS technology. Martin Marietta plans to build these parts at its recently opened $96 million semiconductor facility in Orlando, Fla.

Also in 1985, the CRM and AT&T Bell Laboratories initiated a unique program to share technical information that will lead to development of a new radiation-hardened technology.

The program is being carried out under terms of the AT&T/DOE contract that covers Sandia's operation. A portion of that contract calls for Bell Labs to perform "research and development" for Sandia that DOE, AT&T, and Sandia all deem to be important and appropriate.

In this case, Bell Labs, with CRM radiation-hardening theory and recipes in hand, is developing a technology that will yield fully hardened one-micron CMOS VLSI circuits. The program's current schedule calls for definition of final design rules and process sequences by the middle of this year, and first engineering prototypes by mid-1988.

Significant technology achievements originated at both the CRM and Bell Labs have helped to move this project forward at an encouraging pace.

The CRM, for example, has developed techniques that permit rad-hard chips to have two levels of metal wires (called interconnects).

"Development of a hardened two-level metal IC had been slowed because the additional processing steps required to add a second layer of conducting lines compromised hardness and producibility," says Chuck Gibbon, manager of Integrated Circuit Technology Department 2140. "But the new techniques are producible and can be done without degrading hardness."

"Besides basic VLSI processing," explains Peter Panousis, who heads Bell Labs' VLSI Technology Department, "our contributions include novel approaches that yield thinner and flatter insulative glass layers on ICs, and special resistors that operate consistently over a wide temperature range while providing a shield against cosmic ray-induced single-event upset."

A final type of CRM technology transfer activity involves sharing technical concepts and procedures

(Continued on CRM Eight)

CRM Interconnects: Synoptic History

1960s	Analysis of radiation effects in semiconductors
1972	Completion of initial rad-hard IC designs
1972	First rudimentary rad-hard processing demonstrated
1976	Move to Bldg. 870, the Semiconductor Development Laboratory
1976	First rad-hard large scale integrated circuit — 10-micron features
1978	First rad-hard nonvolatile memory — 10-micron features
1978	First rad-hard microprocessor, RAM, ROM — 6-micron features
1978	First WR delivery
1979	Exchange of 6-micron feature hardening knowledge with RCA
1980	CRM formally established
1980	7/4-micron technology, 7-micron nonvolatile memory demonstrated
1982	Rad-hard equivalent of Intel 8085 microprocessor demonstrated
1982	First rad-hard 16K RAM demonstrated
1983	Begin transfer of 16K RAM technology to Harris Corporation
1983	Begin transfer of rad-hard Intel 8085 equivalent to Harris Corporation and GE
1983	BAO phase-in begins at CRM
1984	Transfer of 4-micron nonvolatile memory to NCR
1985	Complete delivery of more than 20,000 parts for Project Galileo
1985	Begin transfer of 2-micron technology to Martin Marietta
1985	Begin development of rad-hard equivalents of National Semiconductor 32000 microprocessor family
1986	First rad-hard 2-level metal process demonstrated
1986	Begin CRM/Bell Labs development of 1-micron rad-hard technology
1986	Begin development of rad-hard equivalent of Intel 80C51 microcontroller
1986	Begin transfer of 3-micron technology to LSI Logic Corporation
1986	CRM's BAO branch assumes full production responsibility for mature technologies
1987	Move into RHIC-II, a submicron R&D/fabrication facility
1990	RHIC-II fabrication of 1-micron rad-hard parts
1991	Prototype 0.8-micron chip
1994	Prototype 0.5-micron chip

Where the Robot Will Roam

The CRM's new Radiation-Hardened Integrated Circuit lab, called RHIC-II, will be the first IC research and prototype production plant in the U.S. to use a robot in the entire fabrication process.

The robot will travel up and down the 300-foot-long center aisle of RHIC-II's clean room. It'll go freely in and out of any of RHIC-II's 22 specialized processing bays (actually small, individual clean rooms) that can be entered from that aisle.

It'll home in on a plastic "cassette" that holds a 25-wafer lot, pick it up, and move it to another processing bay.

The robot will select its travel route and actions based on information provided by the facility's computerized wafer-fabrication operating system, and by following a reflective tape track that will line floors throughout the 12,500-sq.-ft. clean room area.

"Other wafer fabrication lines have used robots," says Paul Plunkett, supervisor of IC Interconnection & Deposition Division 2132. "However, those robots are confined to specific work stations. The case is the same, in fact, for the robots that do much of the work along a modern automobile assembly line."

Besides being able to receive and execute instructions and to find its way around a large high-tech workplace, the CRM robot will display a new level of sophistication not demonstrated by earlier robots.

Sandia's Intelligent Machine Principles Division 1411 is helping Bruce Draper (2132), the CRM's robot project leader, to develop a force-sensing capability for the automated guided vehicle (AGV), the robot's formal name.

This unique capability will let it know whether it is being gentle enough with the wafer cassettes that are entrusted to it.

Wafers Aren't Cheap

"A CRM wafer lot is so valuable — nominally it represents a resource investment of as much as $100,000 — that we will take extreme measures to protect it during fabrication," Paul explains. "We simply can't have a robot mishandle a lot in any way — we don't want it to drop a cassette, and we don't want it to smash a cassette into a table or a piece of equipment. Even jiggling wafers can reduce product yield."

The know-how residing in Sandia's intelligent machines organization is vital to the CRM's robot project in other ways. "That group is helping us determine the pitfalls of using a robot and how to overcome or avoid those pitfalls," Paul says. "We must ensure that it doesn't place a wafer cassette in the wrong position on a processing machine, or take it to the wrong processing bay.

"Also we must be confident that our robot can perform what will be fairly exacting work," Paul continues. "In some cases, it will have to position a six-inch-wide cassette carefully between two quartz plates on some processing equipment. Those plates are separated by just seven or eight inches."

Just what does a robot add to a complex operation like IC fabrication? First, it ought to play a major role in minimizing clean room contamination. Every time a human process engineer or technican touches a cassette, there's a contamination risk. "That's a considerable risk when you consider that some 200 to 400 steps are involved in processing a wafer lot," Paul says. "By simply using a robot to move wafers from bay to bay, instead of relying on people for that task, we'll significantly reduce the chances of contamination."

In addition, there should be a greater degree of repeatability and control in executing processes on the fabrication line. "Finally, with the robot responsible for certain rather mundane tasks, the living, breathing workers in the RHIC-II facility can devote more of their time to completing the difficult engineering tasks that only they can do," Paul says.

During this year, as RHIC-II construction is completed and all equipment is installed, the robot will be called on only to practice moving cassettes from bay to bay. By the end of 1988, when the laboratory's shakedown period is ending and fabrication of ICs with two-micron-size features starts, the robot will begin loading cassettes into some processing equipment, and removing them after that step is complete.

CRM's robot, purchased from VEECO of Dallas, is already working weekdays in a scale-model RHIC-II process bay in Bldg. 883. There, it's taking commands from a computer and generally carrying them out reliably, even the exercise that simulates placement of cassettes into relatively tight-fitting compartments.

Use of the robot is part of CRM's master plan for almost total automation of wafer fabrication. That will be accomplished by means of the Computer-Integrated Manufacturing (CIM) system, a computer software program developed by Consilium.

CIM, in turn, is part of the CRM's state-of-the-art computer network designed to make the Center run as smoothly as possible. Shortly after RHIC-II is occupied, all Center design and manufacturing operations and all communications will be linked by computers that offer the computational capability of about 150 VAX 780 machines.

Instantaneous Information

"A key to efficient operation is being able to put meaningful information about any aspect of the Center at the fingertips of anyone in the CRM almost instantaneously," says Dave Palmer, IC Simulation & Modeling Division 2112 supervisor. "That's a priority for the network.

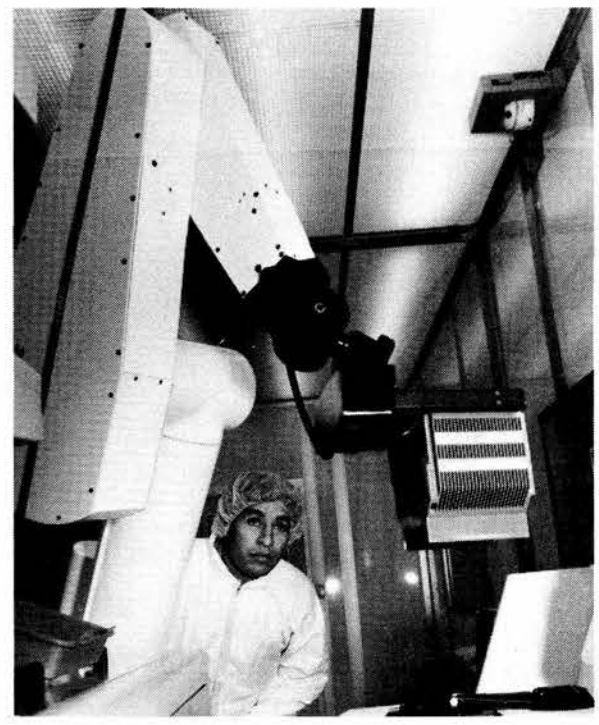
"For instance, I'll be able to get immediate updates on the design status of a specific custom chip's development, or I'll be able to find out the number of chips made during the past year with a certain hardness level," says Dave, who is helping to set up the network. The design and engineering of new microelectronic parts also will be carefully managed, tracked, and aided by the network's computers.

The heart of the RHIC-II Lab is its 12,500-sq.-ft. Class 1 clean room where the robot will roam. This first large-scale Class 1 clean room will limit airborne particles in the work space to not more than one (0.12-micron size or larger) per cubic foot. Clean rooms use laminar air flow, the principle developed at Sandia in 1961 and now adopted worldwide to control airborne contamination (see "Laminar Flow Clean Room").

Besides eliminating virtually all particulates and pollutants from the air, the CRM engineering team, the RHIC-II architect, and other consultants have come up with a wafer development and fabrication showcase that features an environment essentially void of temperature and humidity fluctuations and ground vibrations.

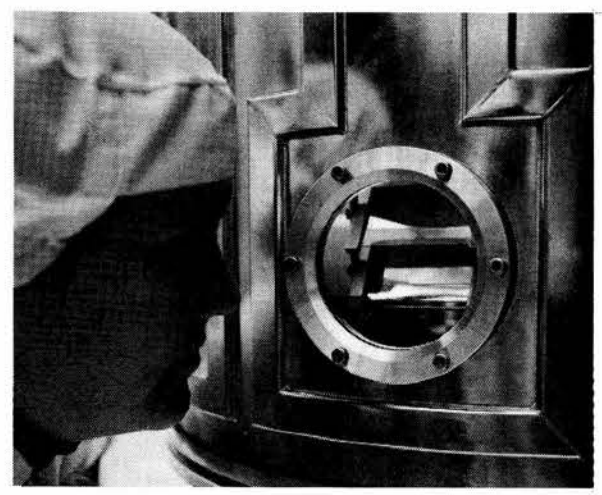
By the end of 1989, RHIC-II should be capable of fabricating about 200 six-inch wafers a month. Then, within the next several years that capacity could reach 400 wafers a month.

RHIC-II's clean room is about half the size of existing clean rooms operating in the commercial sector. However, industry trends suggest that, because of high operating costs, the world-class IC merchant's facility of the 90s will shrink to RHIC-II size.



WILFRED JARAMILLO (2132) watches carefully as the robot that will work in the RHIC-II clean room undergoes some pre-job training in a Bldg. 883 clean room practice area. The robot is holding a plastic wafer cassette that it selected from a storage bin. Here the robot's arm is about to place the cassette on a piece of wafer-processing equipment.

VARIETY OF NEW DESIGN FEATURES will help to make RHIC-II's wafer fabrication area the microelectronic industry's first large-scale Class 1 clean room. A vital, but likely-to-be-overlooked, feature is the clean room ceiling, a completely welded T-bar system with the particulate-removing HEPA filters dry-gasketed into the ceiling grid. Otto Van Geet, Building and Facilities Design Division III 7843, holds a small section of this new ceiling design in his right hand; the older design is in his left hand. The new welded design eliminates small, but numerous and critical, gaps between the short grid sections that must be assembled to make existing clean room ceilings. Microcircuit-killing dust particles, which could flow through these gaps, won't be able to enter the CRM's new clean room. The new dust-blocking design emerged from discussions among CRM engineers, the Plant Engineering RHIC-II project leaders, and RHIC-II's architect-engineer — Anderson, DeBartolo, Pan, of Tucson, Ariz.



ELLEN LEMEN (now 2131 and still with the CRM) looks into a metal evaporation chamber that was used for wafer fabrication in the Bldg. 870 clean room during the late 70s.

BLDG. 870 CLEAN ROOM looked like this in the late 70s. Here Elaine Buck (left) and Melanie Tuck — both still CRM staffers — stand by the now-obsolete wet benches where they cleaned and etched wafers.

IN THE LATE 70s, this photolithography and wet bench area was where wafers went through all photomasking steps during fabrication in the Bldg. 870 clean room. Note air filters in floor and ceiling.

1961 Sandia Invention

Laminar Flow Clean Room Makes It All Possible

The modern microelectronics industry very well could owe its existence to the laminar flow clean room. This 1961 Sandia invention uses a uniform airflow that typically sweeps downward from the ceiling to keep the air in the clean room free of particles, even microscopic ones.

Says Bob Gregory (2100), "There's no way to be sure that some other invention eventually would have come along to permit manufacture of microchips. Lacking that invention, I can guarantee that today's state-of-the-art devices surely could not be built without the environment available in a clean room. And it's been only recently that some alternate concepts have been proposed for interior-particulate elimination."

The various levels of modern microcircuits are literally covered with miles of microscopic metal lines that must be electrically isolated from each other by equally narrow spaces. So, if a particle — even a one- or two-micron-diameter bacterium — adheres to the chip's surface, it probably will destroy that isolation, causing an electrical short.

A manufacturing rule-of-thumb for microchips states that particle sizes equal to one-half the width of a chip's smallest feature can ruin that chip. This means that a single 1/2-micron-wide speck could kill one of the one-micron CMOS chips that the CRM hopes to be making by 1990.

Willis Whitfield (ret.) invented the laminar flow clean room (and was later dubbed "the *real* Mr. Clean" by NBC's "Today Show"). Willis remembers the reaction to the first test of the efficiency of his invention: "When the dust counters went to nearly zero, we thought they were broken."

The early clean rooms reduced the number of particles (0.12-micron-diameter and greater) in typical outdoor air from one million to 10 million per cubic foot to 1000 per cubic foot. (Inside air is not much cleaner: According to an article in *Science 85*, a typical office contains 100,000 to 500,000 particles per cubic foot, and a human being at rest emits about a million particles per minute.) CRM's RHIC-II will be the industry's first large-scale Class 1 clean room, meaning that less than one 0.12-micron particle will be present per cubic foot of air.

Gradual achievements in reducing particle numbers have come primarily because of equipment advances and use of a system design philosophy, not because of refinements of the original concept. For instance, a Class 10,000 clean room cocoons RHIC-II's Class 1 zone. Also, RHIC-II uses improved filters and special welding techniques to prevent the buildup of particles in tiny spaces.

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Tech Transfer

with industry at the numerous technical meetings where CRM researchers present papers. Many of the topics discussed have implications for the silicon semiconductor industry as a whole, not just for that portion of the industry interested in radiation hardening.

Influence on Entire Industry

Two CRM research topics that attracted the attention of IC experts in recent years are studies led by Ron Light, supervisor of IC Lithography & Pattern Transfer Division 2131, and Bob Blewer, Microelectronics Materials & Processes Division 2147.

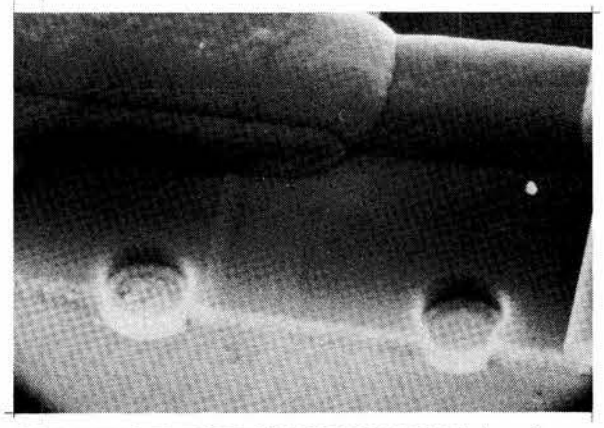
Ron's work advanced the basic understanding of plasma etching, a manufacturing step that selectively removes the thin films deposited on wafers in such a way that specific features, such as lines, remain. "We showed that many related process parameters control plasma etching of aluminum," Ron says. "The interactions are the main reason that it had been so difficult to understand all of the mechanisms governing aluminum etching."

Bob demonstrated that the use of thin, selectively deposited tungsten films may eventually permit the manufacture of more reliable, more complex, and less expensive silicon chips. That could be done, he believes, by using tungsten in addition to polysilicon and aluminum lines to carry electrical signals from point to point on a chip. Tungsten can aid in flattening chip surfaces during fabrication. Maintaining a smooth surface (on any level of a chip) makes it easier to create ICs consisting of several interconnected layers stacked on top of each other.

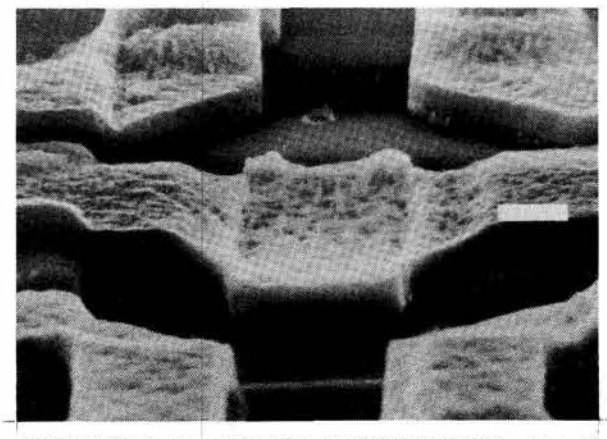
More Coming Up

Technology transfer from the CRM may be expanded even more in the future. Discussions during the past two years with the Semiconductor Research Corporation (SRC) — a research consortium funded by major domestic players in the commercial chip industry — have addressed ways the CRM can be more useful to industry. "As a result," says Bob Gregory, "we're in the formative stages of several joint research endeavors with SRC members."

The SRC has proposed that the CRM evaluate the possibility of seeking to become a national center to help integrate domestic research in semiconductor processing.



SCANNING ELECTRON MICROSCOPE view shows selective formation of tungsten films that reduce processing steps. The films are at the base of circular contact windows in an advanced radiation-hardened IC designed at the CRM. The chip has been cross-sectioned to provide a better view of the 0.2-micron contact window films that self-align among conventional oxide and polysilicon features. Research in selective tungsten deposition is spearheaded by Bob Blewer (2147).



SCANNING ELECTRON MICROSCOPE view of etched aluminum lines demonstrates the CRM's ability to etch vertical aluminum lines on its ICs. Such etching is necessary in order to pack as many features in a given space as possible. The white measurement bar represents two microns on this three-micron CMOS memory device, which can be used for several applications.